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ORIGINAL ARTICLES.

I.—The End of the Trimingham Chalk Bluff.

By Professor T. G. Bonney, Sc.D., LL.D., F.R.S., and the Rev. E. Hill, M.A., F.G.S.

DURING the last six years the sea has continued to encroach on a part of the Norfolk coast, near Trimingham, which has been the subject of much controversy.[1] Our last visit (prior to this year) was in April, 1906, when the most noted of the chalk masses had been reduced to an arch with one pier of chalk and the other of boulder-clay.[2] That was described (with a diagram), and another account, with a photographic illustration, was given in the same volume by the late Mr. W. H. Hudleston, who apparently had not seen our paper.[3]

In April, 1905, the mass of chalk, so frequently discussed by observers before that date, formed the end of a slight headland, the crest of this descending to it from the general level of the top of the cliffs. At that time two other masses of chalk were visible, rising from the beach near the base of the cliff. These are marked, in the reproduction of Mr. R. T. Mallet's[4] photograph, A (the eastern one), C (the central), and E (the western).[5] In 1905 A still formed part of the spur projecting from the cliffs; C, though less prominent, did the same, while E was separated. In 1906 A had been much reduced in size, and separated to form the 'arch'; C was still in contact with the cliff on its southern side, and E had become rather smaller. (The sketch-plan is reproduced on p. 290.)

The changes which have occurred since that date throw some light, in our opinion, on the question whether the historic 'bluff' (A) was a sea-stack or a detached boulder of chalk. The effect of them may be more easily understood by a description of what we saw last

[1] See this Magazine, 1905, pp. 397, 478, 524, 525; and 1906, pp. 13, 400, 525.

[2] For reasons stated in this Magazine (1905, p. 398) we prefer the name of boulder-clay for this material to that of till.

[3] This Magazine, 1906, pp. 400, 525.

[4] See this Magazine, 1905, Pl. XXII (from a photograph by Mr. R. T. Mallet) and a sketch-plan (made by Mr. Hill at Easter, 1905) published on p. 401 in the volume for that year. They are represented (from slightly different points of view) in the photographs illustrating Mr. Brydone's paper: ibid., Pl. III, Fig. 4; Pl. V, Fig. 10; Pl. VIII, Figs. 13, 14; also Pl. IX, Fig. 18.

[5] For reasons given in this Magazine (1906, p. 570), we use the terms 'east' and 'west' for the trend of the coast as more correct than the 'south' and 'north' of earlier observers.

April. On approaching the site of the 'bluff' along the shore from Cromer, we perceived that not only the arch but also the little headland[1] had disappeared; the cliffs rising from a fairly even base to a height of over 150 feet. On the steep face of one of them we noticed a whitish patch, in form a rather elongated oblong, with its base a very few yards above the beach, the colour of which suggested the presence of chalk. Perhaps a couple of hundred yards before reaching it we came upon a well-laminated dark clay,[2] rising from the beach and running obliquely along it to the base of the cliff. After passing it we found the ordinary 'boulder-clay' of the Contorted Drift group

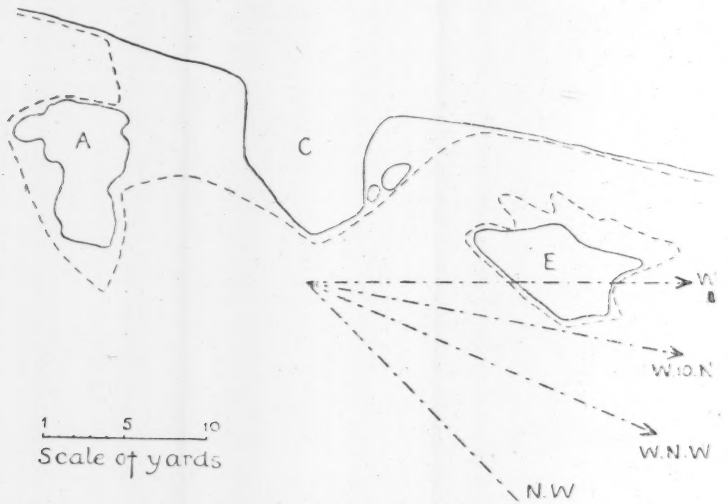


FIG. 1. Sketch-plan (by Rev. E. Hill) of the 'westerly chalk bluff' at Trimingham.[3] The broken line indicates the boundary of chalk or clay in April, 1905; the continuous one that observed on almost the same day in 1906. A, C, E correspond with the masses bearing these letters on Plate XXII, GEOL. MAG., 1905, p. 400.

exposed here and there beneath sand or shingle on the shore, and on arriving at the above-named light-coloured patch obtained the following section. The face of the cliff on either side of it, for some little distance, consisted of a yellowish-grey clayey sand, which here, as is locally not infrequent, was less conspicuously bedded than in many places. The light-coloured patch, which was about 16 yards broad at the base and 18 yards or more in greatest height (the cliff at its back recedes just enough to be out of sight when viewed from the shore[4] at a distance of 30 or 40 yards), included on its eastern side

[1] We believe that this was at the Marl Point of the Ordnance Survey map.

[2] It looked like a representative of the Forest Bed group, but we did not happen to see any rootlets or stems.

[3] Reproduced from Professor Bonney's paper in GEOL. MAG., September, 1906, p. 401.

[4] The tide had not risen much on the occasion of our second visit, when photographs were taken.

a mass of chalk, but mainly consisted of a rather peculiar gravel, formed of irregularly alternating beds, more or less streaky or lenticular, of pebbles and sand (Fig. 2); the latter in one or two places attaining a thickness of 15 or 16 inches, and being fairly free from stones. This and the matrix of the former is a light-coloured quartz-sand, occasionally having more chalky streaks. The fragments of the gravel are mostly chalk and flint. Those of chalk are of two forms, the less numerous being rather well rounded, ranging up to about 4 inches in diameter; but the majority 'tabular' in shape, with

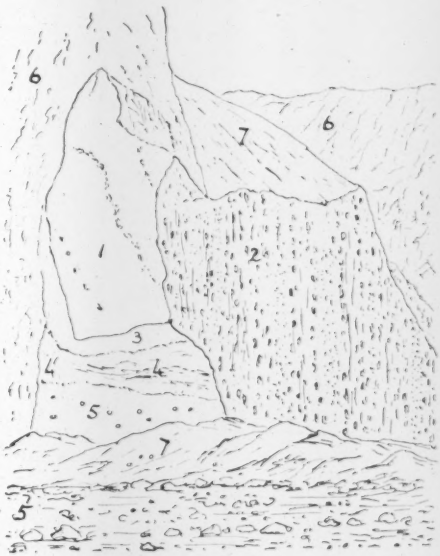


FIG. 2. Diagram of boulder of chalk and associated gravel in Contorted Drift (with Boulder-clay) near Trimingham. Explanation: 1, Chalk with flint. 2, Gravel with sandy beds, bedding nearly vertical. 3, Grey clay. 4, Irregularly banded sand and clay; 4 feet sand. 5, Boulder-clay; 5 feet. Boulder-clay showing on beach in many places. 6, Ordinary clayey sand of Contorted Drift. 7, Slip.

corners and edges somewhat worn, the longer diameter being not infrequently about 5 or even 6 inches. These slabs, since the bedding is now vertical, give a marked character to the gravel. The pieces of flint vary from angular to moderately rounded, and any so much as 4 inches in diameter are rather uncommon. The embedded boulder of chalk contains two distinct layers of flint, the lower more strongly curved than the upper, with indications, as we think, of a third one nearer to the base.[1] This mass and the left-hand part of the gravel

[1] The gravel and the attached chalk are to be seen (though, of course, less clearly than now) on Figs. 10, 11, Pl. V (Brydone, loc. cit.). These indicate that it must have been a few yards farther from Cromer than the right-hand mass of chalk (that marked E in the Plate illustrating our paper in this Magazine for 1905, Plate XXII), or about north of the east end of E in the plan on p. 401

apparently rest on a sort of cushion of stratified clay and sand, the bedding of which in the upper part appears to be rudely conformable with the exterior of the composite boulder; for it first slopes downwards rather steeply (at any rate in the upper part) and then becomes more nearly horizontal. This 'cushion' and the bottom of the gravel rest on a boulder-clay corresponding with that exposed on the beach.[1] The junction on the right-hand side is hidden by a little slipped material, but as the banded clayey sand seems to be thinning in this direction the gravel mass very likely rests at last on the boulder-clay. About 30 yards to the east of this great composite boulder, we found a curious vein-like mass of chalk rising from the beach and running obliquely (westward) for a few yards up the face of the cliff. A layer of coarse gravel adheres to part of its upper surface, and some boulder-clay was seen sticking to the bottom in one place. That clay is also exposed at a distance of a few feet beneath the clayey sand which encloses this chalk.

On the beach, about 30 yards from the base of the cliff, on a line drawn perpendicular to it about half-way between the other two masses, a third piece of chalk was seen rising for only a few inches above the beach, which may be described as a segment of a circle with a chord of about 10 yards and a sagitta, pointing at the cliff, of about 4 yards. Boulder-clay was clearly exposed about it, and appeared to pass beneath its edge, so that we judged the chalk to be a thin slab, the relic of a much thicker boulder. Its position and distance from the cliffs inclined us to the view that it was the last remnant of the historic mass, which in 1906 was reduced to the northern pier of the arch. East of this spot, chalk, obviously in situ, is exposed on the beach within a few dozen yards, so it would probably be struck at a small depth, perhaps hardly a yard, below the base of the cliff.

A word may be added about the two rather long chalk masses, which rise from the shore a few hundred yards nearer Mundesley. They also have suffered from the attacks of the sea, which has washed out a small cove between them. The western one now seems to have its eastern end distinctly pointed—a fairly acute angle, with drift below as well as above—and to be slightly farther away from the sea than the western end of the other mass. The face of that rises directly from the beach, but its eastern end has been worn by the waves into an irregular reef some yards in length, nowhere more than a very few feet above the shore. So that we seem justified in regarding as erratic even these great slab-like masses which formerly suggested the possibility of their being low stacks on a pre-Glacial surface of the chalk, similar to but more prominent than the slight prominences east of Sheringham.

The evidence which has been disclosed by the invasion of the sea

of the volume for 1906, and reproduced here on p. 290, Fig. 1. Our notes in 1905 and 1906 record the presence of a gravel boulder and of what might be chalk, but as the former was not well exposed, and their full bearing on the question could not then be appreciated, we did not mention them.

[1] It was well seen here, and we thought the chalk pebbles became a little less numerous in the middle part of the exposure.

during the last twenty years justifies (in our opinion) the following conclusions:—

A little to the east of the Trimingham section, chalk, with a fairly level top-surface (like an old sea-floor), lies only a few feet below high-water mark. Hereabouts it is covered by a normal boulder-clay, which at this place forms the base of the Contorted Drift, without remains of the Forest Bed or Weybourn Crag. This clay, as a whole, contains many boulders, some of solid, some of *remanié* chalk, and occasionally one of sand and gravel, and we now seem justified in concluding the Trimingham masses to be erratics, not ancient stacks of chalk.

Though the gravel mass at Trimingham is, in at least one respect, unique, we meet occasionally with boulders of stratified sand or gravel. In 1892 there was one, also with its bedding vertical, in the cliffs to the west of Cromer. It had practically disappeared before our next visit, and the place, not far from the end of the lower promenade, is now overgrown with grass.[1] This was a more normal sandy flint-gravel than that at Trimingham, and it contained numerous fragments of marine shells. It was in the usual bedded clayey sands of the Contorted Drift, and so far as we remember was some 40 feet (perhaps more) above the sea. In one respect these gravel and sand boulders are interesting, for the material is incoherent; one could bring it down rapidly with a rake. It therefore could not have been transported unless it had been frozen into a solid mass. In other words, it must have been saturated with water and that have been converted into ice. If it tumbled from a cliff upon an ice-sheet, we are forced to assume that either the latter must have been very thin or the former very high. For an ice-sheet to pluck up from the sea bed a block of this shape would be difficult and still more so to turn it from a horizontal to a vertical position. If we could assume it to have fallen from a cliff upon an ice-foot, and to have been floated away for some little distance, the problem would be simplified, but if so (or in the other case named above) the cliff can hardly have been situated north of the present positions of the boulders, for that hypothesis introduces obvious difficulties. Be this as it may, we need a low winter temperature to convert into solids masses so large as these. It cannot have been less, and may well have been more, than in Spitzbergen at the present day, where the January temperature is about —10° F. with a mean annual temperature of about 18°. That of the Norfolk coast in the Cromer district is about 30° for mid-winter, with a mean annual temperature of about 49°, so there must have been an approximate drop in the one case of 40°, in the other of 31°, which imply a greater fall than is demanded by the indications of the Glacial Epoch in the more central parts of Europe.[2] But to discuss that interesting topic would unduly lengthen this paper, so we must restrict ourselves to calling attention to the above-mentioned facts, and hope to consider them more fully on a future occasion.

[1] So far as I remember, it approached 20 feet in length, and was at the base a little wider than that, but I could not do more than make a rough sketch of it as I was going back to my hotel to return to London. (T. G. B.)

[2] T. G. Bonney, Brit. Assoc. Rep., 1910, pp. 22, 23.

II.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(*Continued from the April Number, p. 147.*)

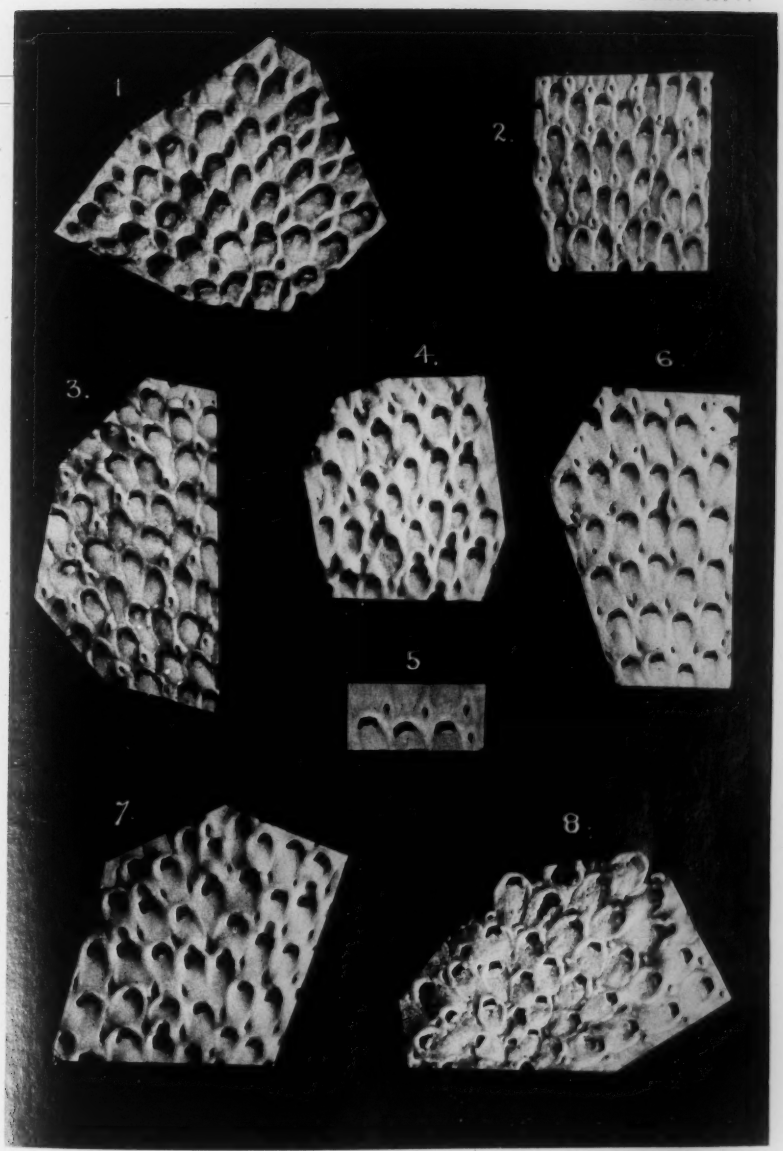
(PLATES XIV AND XV.)

Semieschara Proteus, sp. nov. (Pl. XIV, Figs. 1–8.)

Zoarium always encrusting, with a very strong tendency to linear and in particular transversely linear arrangement, the great regularity of occurrence and the smallness of the avicularia being unsuited to the quincuncial arrangement usual among the Escharidæ.

Zoœcia. If I am right in the extent I assign to this species the range of variation is abnormally wide. The typical form of zoœcium is that met with in the zone of *M. cor-testudinarium*, and exemplified by Figs. 2–5; here the zoœcia are notably long and narrow, ·5 mm. long by ·28 mm. wide being average dimensions; the aperture is small, terminal, and semicircular, but with its sides slightly straightened and its top slightly flattened, and its lower lip is usually gently convex, but also varies between strongly convex and practically straight; the front wall is nearly but not quite flush with the side walls at the foot of the zoœcium, but sinks steadily towards the aperture, and its surface often gives a suggestion of roughness. In the zone of *M. cor-anguinum* (Figs. 6 and 7) the zoœcia are of the same general type, but are wider in proportion, with average dimensions of ·52 mm. in length and ·35 mm. in width; the front wall not only rises flush with the side walls at the foot of the zoœcium but often swells up above them, while it sinks to a greater depth at the aperture and is smooth almost to sleekness; the lower lip of the aperture still varies between strongly convex and practically straight, but the *average* convexity is less than in the preceding zone. In the very rare form from the zone of *H. planus* illustrated by Fig. 1 the zoœcia are of quite different shape, ·55 mm. long by ·4–·45 mm. wide being average dimensions; the front wall is well below the side walls at the foot of the zoœcium and sinks but little towards the aperture, and its surface is strongly roughened; the aperture is large and its lower lip projects very prominently, leaving a deep, wide, blunt-ended sinus on either side of it. In the upper part of the zone of *A. quadratus* there occurs quite rarely the form illustrated by Fig. 8; here the zoœcia have very similar dimensions to the *planus* form and also its rough front wall, but the front wall rises above the side walls at the foot of the zoœcium, though even so it is still below the end wall of the preceding zoœcium, and it sinks moderately towards the aperture, which is large and has its sides distinctly straightened by what appears to be a definite infold of the side wall, and a lower lip, which is either practically straight or only slightly convex; in this form alone is there any tendency to separate side walls for adjoining zoœcia.

Oœcia small depressions in the foot of the succeeding zoœcia, but embraced by the end wall and covered in with an inconspicuous narrowly heel-shaped roof with a concave free edge; they occur frequently, but are generally only evidenced by the bulged end wall



E. M. Brydone, Photo. Bemrose, Collo.

Chalk Polyzoa.

at the head of the zoœcium with a depression between it and the aperture; in the *quadratus* form they are exceptional, being large and globular.

Avicularia small, mandibular, very abundant, and typically placed interstitially at every meeting-point of four zoœcia, with the beak directed upwards, and generally, but not (e.g. Fig. 3) invariably, in the zones of *M. cor-testudinarium* and *M. cor-anguinum* fused with the surrounding zoœcia. In the zone of *H. planus* they are wide (about ·3 mm. at maximum width) and stumpy with circular apertures, from the lower side of which a slender sinus runs a short way downwards in the middle line. In the zone of *M. cor-testudinarium* they are reduced in width by about half, the side walls rise considerably, the beak when distinguishable is long and narrow, and the aperture is smaller in proportion, definitely elliptical, and often without sinus, the latter when present being much reduced in length. In the zone of *M. cor-anguinum* the lateral compression has increased to a point at which they are often little more than wide cracks between the zoœcia; the aperture when visible is still elliptical, but narrower, and shows no trace of a sinus. In the zone of *A. quadratus* the avicularia are apparently much shorter and wider again, but one of the side walls seems to have been squeezed upwards and inwards until it almost wholly overhangs and conceals the aperture; the outlines of the avicularia are very faint and uncertain.

The early and late forms of this species differ so markedly from the general type that they might easily be treated as separate species, and it is only the progressive series afforded by the avicularia which has decided me to act on a strong general impression that they are all variations of one very plastic species. I propose, however, for the present to distinguish the *planus* form as var. *lateaperta* and the *quadratus* form as var. *peneclausa*.

The form described by D'Orbigny as *Reptescharinella transversa* comes near this, but is easily distinguishable by the avicularia pointing downwards.

Semieschara Woodsi, mihi.[1] (Pl. XV, Figs. 1–5.)

Semieschara Pergensi, mihi.[1] (Pl. XV, Figs. 6–11.)

I take this opportunity of giving photographic figures of these species, as the original figures, which were based upon my probably diagrammatic sketches, are not very adequate. In each case the type is unfortunately not well adapted to photography, and has required to be supplemented by other specimens. In the case of *S. Woodsi* I am now convinced that what I described as the upper lip of the aperture sloping sharply inwards is the upper surface of the butt end of the succeeding zoœcium, visible within the upper part of a large semicircular aperture; round pores are sometimes visible in its end wall, and this is well shown by several zoœcia of the type-specimen, which was therefore specially lighted to bring out this feature as far as possible. The aperture of the avicularium seems very variable both in size and shape, the prevailing shape being elliptical, not

[1] Geol. Mag., July, 1906.

circular. The earlier forms have as a rule sharper features than the later. The oœcia (Fig. 5) are very simple, very little more than mere swellings.

In the case of *S. Pergensi* the original figure was quite inadequate and must be withdrawn. The type was unfortunately selected from a horizon at which various delicate features presented by the early forms had got blunted or obscured. In the early forms from the lower part of the zone of *A. quadratus* the zoœcia are separated by definite sutures which enable a distinction to be easily drawn between the not infrequent accidental swellings of the foot of a zoœcium, which stop short at the suture, and the rather larger swellings which pass across and hide the suture and are oœcia (Fig. 9); the little infolds of the side walls, which give a trifoliate appearance to the aperture, are sharp and strong in the early form, but tend to die away in the later forms, as e.g. in the larger zoœcia in the figure of part of the type, though occasional specimens and zoœcia continue to develop them well (e.g. Figs. 7 and 8). The avicularia in the early forms prove to be of the hourglass type, with a long elliptical aperture and side walls gently infolded over a considerable length, and at their maximum of infold slightly overhanging the aperture, below which point they return rather sharply; a tiny blunt denticle is often found projecting into the aperture from the middle of its lower end; the bounding sutures (slightly exaggerated in the figures) show that a deep cavity is hollowed out in the lower end of the succeeding zoœcium in order to receive the low upper end of the avicularium. In the later forms the avicularia tend to broaden and flatten out and the infold of the side walls and the apertural denticle become very faint or disappear.

EXPLANATION OF PLATES.

PLATE XIV.

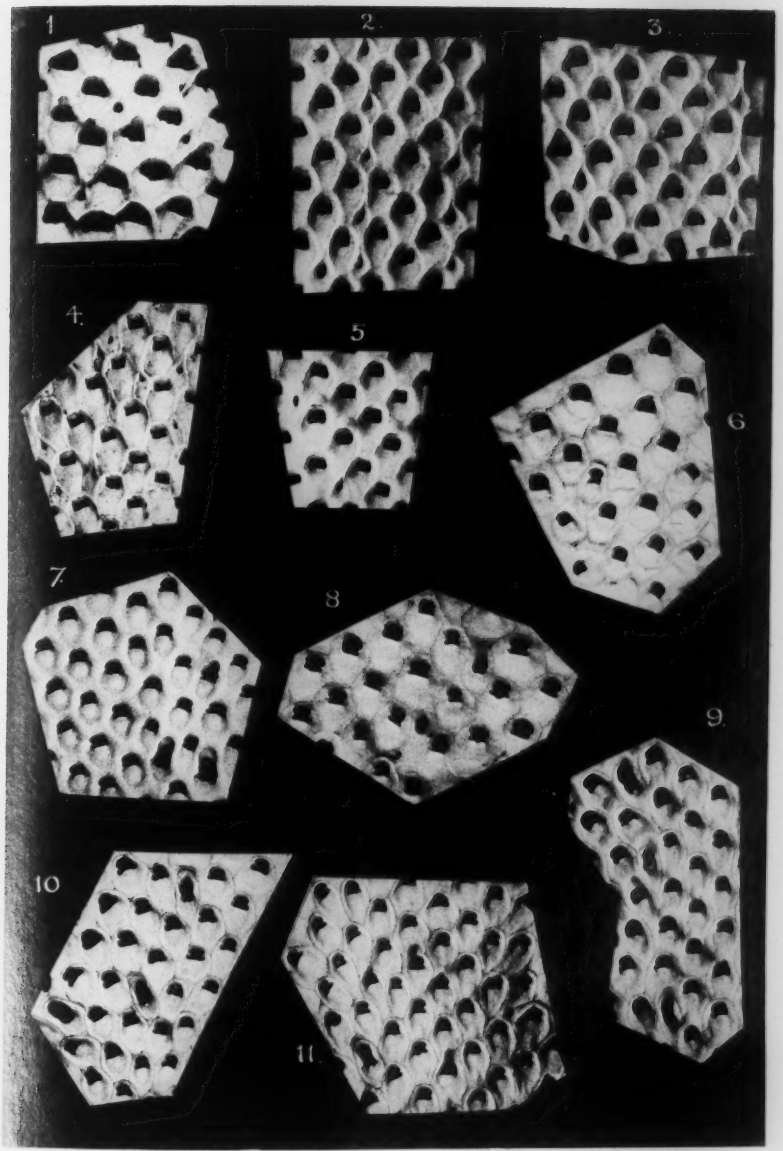
(All figures × 12 diams. unless otherwise stated.)

FIG. 1. *Semieschara Proteus*, var. *lateaperta*. Zone of *H. planus*, Froxfield, Hants.
.. 2. *Semieschara Proteus*. Zone of *M. cor-testudinarium*, Seaford.
.. 3. .. .. .. Privett, Hants.
.. 4. .. .. .. Seaford.
.. 5. .. .. × 21.
.. 6, 7. .. .. *M. cor-anguinum*, Gravesend.
.. 8. *Semieschara Proteus*, var. *peneclausa*. Zone of *A. quadratus* (subzone of ditto), Shawford, Hants.

PLATE XV.

(All figures × 12 diams.)

FIG. 1. *Semieschara Woodsi*. Zone of *B. mucronata*, Portsdown (type-specimen).
.. 2, 3. .. ..
.. 4. .. Subzone of *O. pilula*, West Meon, Hants.
.. 5. .. .. *A. quadratus*, Shawford, Hants.
.. 6. *Semieschara Pergensi*. Zone of *B. mucronata*, Portsdown (type-specimen).
.. 7, 8. .. ..
.. 9–11. .. Subzone of *E. scutatus*, var. *depressus*, Brighton.



E. M. Brydone, Photo. Emrose, Collo.

Chalk Polyzoa.

III.—A New Species of *Fibularia* from Nigeria.

By Herbert L. Hawkins, M.Sc., F.G.S., Lecturer in Geology, University College, Reading.

(PLATE XVI.)

Among a series of fossils collected in Southern Nigeria by Mr. A. E. Kitson, and submitted by him to the authorities at the British Museum, are some small Echinoids. Dr. Bather has kindly allowed me to examine them, and, as they appear to belong to a new species, I have drawn up the following description. For reasons stated below I ascribe the forms to the genus *Fibularia*, Lamk., and consider all the specimens to belong to the same species. Ten individuals have been used for the purposes of the description, but, to prevent possible confusion, I select that numbered A as the type-specimen.

All the examples are preserved in a pale-yellow, calcareous sandstone of fine grain. Unfortunately the sand grains have often been pressed into the tests, leaving a scarred surface on which it is difficult to trace tubercles or sutures with any certainty. By staining some of the specimens with aniline green, the pores of the ambulacra, the tubercles, and to some extent the plate sutures, were rendered visible, and all the details of structure given below are taken from those examples (Nos. A, B, E, G, H, and K).

Fibularia nigeriæ, sp. nov.

The following are measurements (in millimetres) of the nine complete specimens examined:—

	Ant.-post. diam.	Transv. diam.	Height.	Length of ant. petal.
A . .	8·8	7·8	8·1	2·8
B . .	11·1	10·8	10·4	3·0
C . .	8·8	7·1	7·1	2·5
D . .	10·0	8·6	9·0	3·1
E . .	7·2	5·7	5·9	2·0
F . .	8·9	8·1	7·5	?
G . .	7·6	7·2	7·0	2·1
H . .	6·7	6·1	5·7	2·1
J . .	7·9	7·4	7·1	?

Shape.—As the above measurements show, the shape of the test varies very considerably. Individuals may be either elongated or approximately circular, without regard to their size, so that the ambital outline does not necessarily show a change in character during growth. All the specimens agree in being to some extent longer than broad. The test is extremely elevated, having usually almost the same height as breadth; while, in the most elongated examples (A and D), the height actually exceeds the breadth.

The apex of the test is central, and coincides in position with the madreporite. From this point the test slopes down gradually for

a distance corresponding closely with the length of the ambulacral petals. Beyond that region a very sudden increase in declivity appears, and the walls of the test become almost vertical. It is impossible to ascertain where the adoral surface begins, as the margin of the test is perfectly rounded. The maximum diameter is at a level approximately two-thirds of the distance from the apex to the base. In the forms which approach most nearly to a globular shape, there is a tendency to a slight flattening of the adoral surface over an area whose radius is the line from the centre of the peristome to the adapical margin of the periproct. There may even be a slight concavity in this region. But in the elongated forms no such flattening is developed, so that the specimens will not stand on the adoral surface, but lie on one side.

An important feature which is shared by all the specimens is the carinated character of the ambulacra, and a consequent alternation of concavity and convexity in the ambital outline, comparable with that of many species of *Clypeaster*. (This is shown, to a slightly exaggerated degree, in Pl. XVI, Fig. 4.) The interambulacra are slightly sunken, chiefly along their median sutures, and the perradial parts of the ambulacra are equally depressed. But on the ambulacral areas, less than half-way between the interradial and perradial sutures, a more or less prominent elevation passes down from the ends of the petals almost to the peristome. The carinæ are more prominent in the elongated forms, but are quite obvious even in the most spherical.

The Ambulacra.—The ambulacra are petaloid for from eight to fourteen of their plates from the apex (according to the size of the specimens), and increase considerably in width below the petaloid region. They become rapidly narrower below the ambitus, but occupy most of the peristomial margin. The width of the ambulacra is to that of the interambulacra (measured at the ambitus) as 5 : 3.

The posterior petals are very slightly shorter than the others, and in elongated specimens the lateral ambulacra are perforce shorter than the anterior. The plates are all primaries, but are often cuneiform. The petals are in a few instances slightly, but definitely, inflated, but are usually flush with the test surface. The number of pores in the petals shows an increase, following the growth in size of the individuals, but slight variations in the number (of quite an irregular type) often occur in the petals of a single specimen. The pores are rounded or elliptical, no regular difference being shown between those of the outer and inner series. They are very large in proportion to the size of the test. The two pores of a pair are set obliquely, sloping interradially and adorally, and are joined by a shallow groove of a width equal to the diameter of the pores. The obliquity of the pore-pairs becomes more intense as they are traced outwards from the apex, so that the inner row of pores is more closely packed than the outer. The last three or four pore-pairs on each half area pierce a more perradiad part of the plate than the upper series. This gives a tendency to a closing of the petals, a feature which is more apparent than real, as it is exaggerated by the extreme obliqueness of the distal pore-pairs.

As far as I have been able to ascertain, there are no other pores in

the petaloid region of the ambulacra, nor any pores like those of the petals in any other part of the areas excepting on the peristomial margin.

Below the petaloid part of the areas the plates become considerably larger, increasing in both height and width. At the end of the petals the transverse sutures are practically horizontal, but below the ambitus they become oblique to a variable degree, sloping downwards towards the interradial margins of the areas. The height of the plates remains constant throughout the non-petaloid region. On the actual border of the peristome, one pair (rarely two pairs) of pores occur in each ambulacrum. These pores are not quite so large as those of the petals, and only become visible when the specimen is stained.

On all the plates from the petals to the peristome, there occur, instead of the normal pore-pairs, rows of minute perforations similar to those in *Echinocyamus pusillus* and many other Clypeastroids. The main series of them form transverse rows, parallel with, and immediately adoral to, the transverse sutures. Towards the interradial sutures these rows curve slightly in an adoral direction, and mingle with scattered pores (often grouped obscurely in sets of three) which occur over the whole plate area. The relations of these small pores are shown in Pl. XVI, Fig. 9. They can only be seen in stained specimens, and then usually with difficulty. On slightly etching one example with acid, their disposition was clearly shown. The figure is adapted from that specimen, the tuberculation being inserted from a different individual.

The Interambulacra.—Between the petals the interambulacra are very narrow, and, through almost half that region, are composed of single deltoidal plates bearing vertical rows of tubercles. The areas widen out towards the distal end of the petals, but are soon narrowed by the renewed expansion of the ambulacra. The plates are, for the most part, rather higher than broad, and one of them corresponds to rather more than two of the extra-petaloid ambulacrals. The tuberculation is sparse, and uniform in character. The tubercles are deeply scrobiculate, and appear to be imperforate. On the adoral surface the interambulacra become rapidly narrowed towards the peristome. I have not been able to trace the plate sutures with certainty in this region of the test, but the evidence seems to indicate that there is a single, narrow plate separating the ambulacrals on the peristomial margin, as in the majority of the Clypeastroida.

The Peristome.—The peristome is central and small, being only 0·9 mm. in diameter in specimen B, the largest examined. It is obtusely pentagonal in outline, the angles of the pentagon corresponding to the radii. The mouth opening is wider on the outer surface of the test than within, and on the bevelled edge of the peristome one, or more rarely two, pairs of large pores are situated. (In specimen B there seems to be a single pore only in each ambulacrum, proportionately larger than in cases where two pores exist.)

The Periproct.—The periproct is situated about midway between the peristome and the ambitus (when measured tangentially). It is always smaller than the peristome. The aperture is almost circular in most cases, sometimes showing a slight elongation in the direction

of the interradial suture. The test is thinner than at the peristome, and the edges of the periproct show no trace of bevelling.

The Apical System.—The apical system is central, and, as is usual in Clypeastroids, shows no signs of the plate sutures. The madreporite is in the centre of the system, and is prominent. It is multiporous, the greatest number of perforations being congregated in its posterior part. There are four genital pores, all considerably larger than those of the petals. They pass through the test at the same distance from the apex as do the proximal petal-pores, so that either they are at the outer margins of the genital plates, or else the latter project considerably into the interambulacra. The ocular pores are very minute, and can with difficulty be seen, even after etching with acid and staining the specimen. They are slightly sunken below the surrounding level of the test.

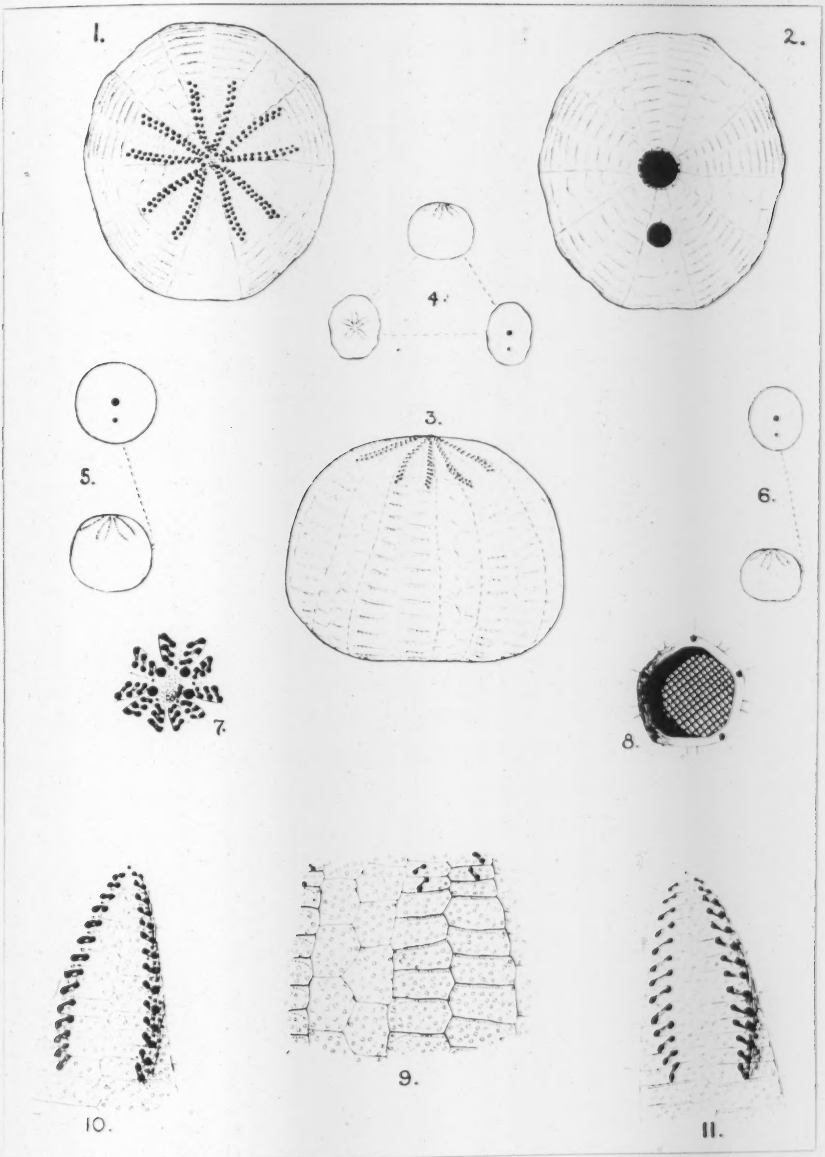
Comparison with other species.—In view of the fact that all the specimens are very much elevated, and the broken specimen (K) shows no trace of interradial buttresses, I refer the species to *Fibularia* as Clark has recently defined the genus (Ann. Mag. Nat. Hist., ser. VIII, vol. vii, p. 605). Probably, if any sound generic distinction separates the *Thagastea* of Pomel from *Fibularia*, it should join the former group; but I am not satisfied that the genus is distinct. The only anomalous feature in *F. nigeriæ*, which renders its generic position doubtful, is the slight inflation of the petals, and the shallow grooves which connect the pores in that region. It is possible that this may mark an important difference, since the opposite conditions prevail in most *Fibulariæ*, but with the material available it seems best to admit the species to that genus.

The only species with which I am acquainted that bears any close resemblance to *F. nigeriæ* is the *F.* (*Thagastea*) *luciani* (de Loriol, 1880), originally described from the Middle Eocene of Egypt, and recently discovered by Dr. J. W. Gregory at the same horizon in Cyrenaica. The proportionate height (compared with the length) of *F. nigeriæ* is, however, persistently greater than in either de Loriol's or Gregory's specimens. Adding to this extreme elevation of the test the peculiarities of the petals and the carinate shape of the test, sufficient contrasts exist to distinguish at once the Nigerian species from *F. luciani*. These same features serve to separate *F. nigeriæ* from all other species of the genus, since *F. luciani* is the most elevated of all previously described.

Locality and Horizon.—The specimens were collected at Bende, Southern Nigeria.

The exact horizon of *F. nigeriæ* cannot be ascertained. It might well be ascribed to the Lower Tertiary, probably Lower or Middle Eocene, since the genus *Fibularia* was apparently not well established before then. The elaboration of the petals tends to support the view that it is by no means the earliest species of the genus. It is, however, within the bounds of possibility that it may be of Maestrichtian age, though its general characters render it more likely, to my mind, that it belongs to a later horizon.

The specimens are preserved in the Department of Geology, British Museum (Natural History).



L. L. Hawkins del.

Fibularia Nigeriæ, sp. nov. ? Tertiary. Southern Nigeria.

EXPLANATION OF PLATE XVI.

FIBULARIA NIGERLÆ, n.sp.

FIG. 1. Adapical surface of A (type-specimen). ×4·5.
,, 2. Adoral surface of A. ×4·5.
,, 3. Lateral view of A. ×4·5.
,, 4. Same specimen. Nat. size.
,, 5. Specimen B. Nat. size.
,, 6. Specimen C. Nat. size.
,, 7. Apical system of B. ×12.
,, 8. Peristome of B. ×12.
,, 9. R. post. amb. and iamb. of K. ×9.
,, 10. Ant. petal of B. ×9.
,, 11. Ant. petal of A. ×9.

IV.—NOTES ON DESERT-WATER IN WESTERN AUSTRALIA. 'GNAMMA HOLES' AND 'NIGHT WELLS'.

By MALCOLM MACLAREN, D.Sc., F.G.S.

IN the arid region of the goldfields of Western Australia a knowledge of the conditions under which a search for water is most likely to be rewarded is of prime importance to the prospector who may find himself away from the beaten tracks. There is, in the summer, little hope of finding fresh water in the long narrow bands of gold-bearing greenstone-schist that run from N.N.W. to S.S.E. through Western Australia, for both the surface and the deep-seated waters of this rock-formation are then salter than those of the sea. When unprovided with 'condensers' for the distillation of these waters, the prospector must therefore turn towards the neighbouring granitic areas, and search either for 'soaks' or for the remarkable 'gnamma'

FIG. 1. Cross-section of typical 'Gnamma' hole.

holes of the bare rocky ridges. The first and most reliable of these sources of fresh water — the 'soaks' — presents nothing abnormal and requires little description. They are found in the sandy hollows at the foot of granite slopes. A well is sunk in the sand, and the water is baled as it slowly percolates into the bottom of the hole. The supply may vary from a mere trickle to several hundred gallons in twenty-four hours, according to the catchment, to the season, and to the permeability of the sand that has protected the water from evaporation since it was collected in the rock-hollow.

Where the absence of soaks is indicated by the non-appearance of the slightly greener vegetation that grows over them, the traveller abandons the lower ground and searches the bare rock-outcrops for rock-holes, or 'gnamma' as they are called by the natives.

Gnamma holes are most common in granite areas, but are occasionally to be found in the quartz-porphyry and soda-porphyry dykes that seam the greenstone-schists. Somewhat similar rock-holes may occur in the lateritic deposits that mask the greenstone-schists, but they are there very rare. The normal shape is usually that of an ordinary water carafe, having a comparatively narrow cylindrical orifice and widening out greatly below (Fig. 1). Their capacity varies from a few gallons to several hundreds and even thousands of gallons, and several may be found on the one rock slope. Like the soaks they are dependent on the rainfall of the previous winter. Under favourable circumstances they may obtain sufficient water to last throughout the summer, but they cannot, in individual cases, always be relied upon. The scanty rains of the eastern desert are erratic in distribution, falling always as a few heavy local showers, so that a given rock slope may escape the rains of a whole winter. The water of these gnamma holes, forming as it does the principal summer supply of the wandering aboriginals, is carefully preserved by them both from evaporation and from marsupials, reptiles, and birds, by covering the water with eucalypt foliage, and the orifice with flat stones.

The occasional occurrence of these peculiar rock-holes at the intersection of or along joints in massive granite gives some clue to their origin. They apparently arise in the first place from the flaking off by insolation of small fragments along the walls of the joint. In the cavity thus formed (generally on a smooth sand-swept rock surface) a little water lodges, in time decomposing the felspathic member of the rock, and freeing the quartz-grains which are swept from the shallow depression by the high winds of the desert. Seasonal repetition of this process slowly deepens the hole beyond the reach of the wind. The sand now retains the water, and the sides and the bottom of the cavity are alone attacked, and the hole grows in size horizontally and vertically. The orifice is protected from enlargement partly because there is no standing water to act on its sides, but much more because of the siliceous cementation that has taken place at and near the rock surface in its neighbourhood, as a result of the upward capillary movement of the silica dissolved in the course of the decomposition of the felspars of the granite. This superficial cementation is characteristic of this desert region, and has its utmost expression, as I propose to show in another place, in the formation of beds of siliceous 'laterite' 30 and 40 feet thick, comparable in respect of origin with the ferruginous laterites of the greenstone-schist areas. To it must be ascribed the unique form of these granite rock-holes. The process of internal enlargement has probably been greatly accelerated by the removal of the sand from the bottom by human agency, since the position of all these rock-holes is well known to the aboriginals, who, indeed, govern their migrations by the location and capacity of the various gnammas.

In the camp-fire conversation of the West Australian prospectors and cattlemen, the all-engrossing subject is water, and, when on this topic, it is seldom long before the 'night wells' are mentioned (Fig. 2). These are described as rock-holes dry by day, but furnishing an

abundant supply of water at night. They are regarded as mysterious and indeed somewhat uncanny, since their nocturnal flow is always preceded by weird hissings and by hollow sounds of rushing air. Certainly no explanation of the undoubted fact that water appears in them at night only, during the summer season at any rate, has, so far as I know, yet been advanced. How many 'night wells' there are I have never been able to ascertain. The cattlemen speak of several, but are hazy as to their geographical position. In March, 1911, I had an opportunity, while driving across country from Ravensthorpe to the railway station at Broomehill, in the south-western portion of the State, of visiting for a few minutes the only night well whose position I could definitely fix. It lies between Magitup and Cowallellup (Carollillup) in lat. 34° 5′ and long. 118° 25′.

The 'well', or rather rock-hole, is situated on the top of a rounded boss of platy granite-gneiss, standing from 6 to 8 feet above the bed of a stream of the usual West Australian type, the course of which is marked across the plain by a double line of large she-oak and paper-bark trees. Along the sandy creek bed were several pools of salt water, from which the salt was beginning to crystallize out on the margins, for it was then long since rain had fallen. I had

FIG. 2. Cross-section of 'Night Well'. A, trough; B, internal cavity; C, C, vertical joints.

expected to find in the night well an ordinary gnamma hole, but it differs materially from these. Across the boss there ran two vertical joint-planes, 2 feet apart at the widest portion exposed, but almost meeting at the other end of the bare rock surface, which was some 60 by 30 feet in area. For a length of 15 feet the rock between these joint-planes has been removed, yielding a trough with a width of from 18 to 30 inches and a maximum depth of $2\frac{1}{2}$ feet. Throughout the summer this trough is empty by day, but contains from 12 to 18 inches of water at night. Near the bottom of the trough, and in the rock wall of one side, was a horizontal rift extending the whole length of the trough, and marking the plane of separation of a thin surface plate of gneiss from the main mass below, and it was through this rift that the water appeared and disappeared. The platy granite-gneiss here found is by no means common in Western Australia. This, indeed, is the only spot at which I saw it during traverses covering many hundreds of miles. It is, however, recorded by the Geological Survey from near Northampton, and also in the Gascoyne and the Pilbara region in the north-west of the State. While a portion of the water contained in the cavity that clearly exists beneath the surface-shell of gneiss is probably

derived from the rainfall caught on the bare rock surface, the top of the gneiss boss is yet not too high above the stream bed to be beyond the reach of the flood waters arising from the few torrential storms in which the whole annual rainfall (12 inches) of the district falls. No other features bearing on the problem were observed; still, these facts and the attendant climatic conditions are sufficient to indicate a feasible explanation of the phenomenon.

The shell of gneiss, except beneath and at the side bordering on the trough, is in continuity with the mass of the rock. The diurnal range of temperature on the rock surface is considerable in the summer—certainly not less than 100° F. During the day the shell of gneiss, prevented from horizontal expansion on three sides, springs to an arch, and the water in the trough retreats—probably entirely by gravity—through the rift. At night, with a considerable fall in the rock temperature, the shell contracts, and settling down, forces, firstly, air through the narrow irregular rift (hence the whistling and hissing sounds that for half an hour precede the appearance of water in the trough) and finally water, which reaches its maximum height in the trough about daybreak. The first appearance of the water generally occurs about 8 o'clock at night. The expulsion of air prior to that of the water indicates that the water is withdrawn within the rock by gravity and not by any siphon effect. Since the linear expansion of gneiss is approximately only one part in 200,000 for every degree Fahr., the cavity must be large and the adjustment of level fairly delicate. This, indeed, is also indicated by the fact that, for some time after heavy rains, water remains during the day in the outer trough. In the absence of any evidence of displacement of the outer shell of gneiss, it may be assumed that the internal cavity has been assisted in reaching its obviously large dimensions by disintegration of its walls in the same manner that a gnamma hole grows.

V.—On the Recognition of Two Stages in the Upper Chalk.

By A. J. Jukes-Browne, F.R.S., F.G.S.

WHEN writing a general account of the Upper Chalk of England for vol. iii of the *Cretaceous Rocks of Britain* (Mem. Geol. Survey, 1904), I stated the belief of Mr. W. Hill and myself that the British Upper Chalk comprised more than one division of the value of a stage. We grouped the zones then recognized into two divisions, pointing out that the lower zones were essentially the Chalk with Micrasters and the upper zones the Chalk with Belemnites; but we did not systematically adopt these divisions as stages with definite names.

It was remarked (op. cit., p. 5) that "Our knowledge of the several faunas is not yet sufficiently complete to enable us to say precisely where a line could best be drawn between the two divisions or stages, and it is possible that some modifications of the zones will have to be made before two such stages can be established. Moreover, if such a division be found natural and desirable the existing

nomenclature of the Chalk will have to be abandoned, for the formation will then be divided into four parts instead of three, so that the names Lower, Middle, and Upper could no longer be retained. The time has hardly yet arrived for this change to be made, but Mr. Hill and I wish to express our belief that it will come, and that some scheme of nomenclature more resembling that of the French geologists will have to be adopted for the Upper Cretaceous Series of England".

Nearly ten years have passed since the above was written, and the further researches which have been made since that time have only tended to strengthen our belief, but have at the same time shown the wisdom of waiting for more evidence before deciding where the line between the two divisions of the Upper Chalk should be drawn.

A more careful consideration of the question has convinced me that the distinction between these two portions of the Upper Chalk is less marked in England than it is in France or Germany. In England there is little variation in the lithological character of the deposit, which consists of nearly pure chalk throughout a thickness of some 1,100 feet. As a consequence the fauna has a similar facies throughout, and there is a complete passage from each zone to the next one, so that many species range from one into another. Moreover, all kinds of Cephalopoda except Belemnites are rare, so that it is impossible to use Ammonoids as zonal indices, and we are obliged to have recourse to Belemnites and Echinoderms.

On the other hand, in parts of France and Germany the pure chalk passes into other kinds of calcareous deposits, such as argillaceous marl, marly limestone, Bryozoan and siliceous limestones. Moreover, Ammonites are much less rare, and M. de Grossouvre has shown that a reliable zonal classification can be established on the recorded occurrences of the different species. There is also a greater number and greater variety of Echinoderms on the Continent than in England, so that the faunal difference between the one set of zones and the other is more apparent. Probably when the Brachiopoda have been more fully studied they also will show a more restricted range of species and varieties.

The cause of this more marked difference of fauna on the Continent is doubtless the fact that parts of the European region were land during most of the Cretaceous period, and that there was a greater variety of life in the shallower waters near the land-tracts than in the deeper water which lay over the British area and the greater part of the Paris Basin.

Before proceeding any farther it is necessary to make some remarks on the zonal division of the Upper Chalk. Until recently only six zones were recognized as its components in the South of England, but so long ago as 1899 and 1900 Mr. A. W. Rowe remarked that the true *Actinocamax quadratus* is so rare a fossil in England that *Offaster pilula* would be a better index fossil for the zone which has hitherto gone by the name of the former. At the same time he pointed out that *A. quadratus* only occurs in the higher part of the zone, the form found in the lower part being *A. granulatus*.

More recently Messrs. Griffith & Brydone have proposed to divide

this zone, as developed in Hampshire,[1] into three sub-zones, viz.: (1) a sub-zone of *Echinocorys scutatus*, var. *depressa*, (2) a sub-zone of *O. pilula*, and (3) a sub-zone of *A. quadratus*. Mr. Brydone informs me, however, that he has since come to the conclusion that it will be better to make two distinct zones out of this great thickness of chalk, a lower zone of *O. pilula* and an upper one of *A. quadratus*. This proposal has the advantage of agreeing with the zonal divisions adopted in Germany, where this portion of the Chalk has been divided by Schlüter into a lower zone of *Scaphites binodosus* and a higher one of *A. quadratus*.[2]

In France also two zones have been recognized in this part of the Chalk; by J. Lambert in the Department of the Yonne, by A. Peron in the vicinity of Reims and Epernay, and in Aquitaine by Arnaud.

In the Yonne a series of zones was established by Lambert[3] and indicated by letters, his zone M being about 100 feet thick and corresponding with the *O. pilula* zone of Mr. Brydone, for it is characterized by the abundance of *O. pilula* with what is now known as *A. granulatus*. His zone N, about 130 feet thick, corresponds roughly with that of *A. quadratus*, its special fossils being *A. quadratus*, *Offaster corculum*, and *Micraster Schroderi* (= *M. glyphus* in Lambert's papers).

The same two zones can be recognized in the Marne near Reims where A. Peron[4] has shown that the 'craie à *A. quadratus*' is divisible into two zones, a lower one characterized by *Micraster gibbus*, var. *fastigatus*, Gauthier, and an upper one with *M. glyphus* (= *Schroderi*) and *Salenia Heberti*. *Offaster pilula* is also common in the lower zone and rare in the upper. In Aquitaine a similar succession of zones has been established by H. Arnaud,[5] and lettered in a similar manner from A to S. Of these the zone P^1 (= that of *O. pilula*) is characterized by the occurrence of *Micraster regularis*, *Echinocorys orbis*, and *Pyrina petrocoriensis*, and M. de Grossouvre has shown that its special Ammonite is *Placenticeras bidorsatum*. The zone P^2 (= that of *A. quadratus*) is a sandy chalk with few fossils except bands of *Ostrea vesicularis*, but examples of *A. quadratus* and *Mortoniceras delawarense* have been found in it.

From these observations it is clear that both in the South of England, the North of France, and in Aquitaine, the mass of chalk which lies between the zone of *Marsupites* and the Chalk containing *B. mucronata* is divisible into two distinct zones which are recognizable by the occurrence of certain species of Echinoderms and Belemnites, apart from the rarer occurrence of Ammonoids. Thus, if the zone of

[1] *The Zones of the Chalk in Hants*, by C. Griffith & R. M. Brydone (Dulau & Co., 1911), pp. 3, 10.

[2] See Schlüter in *Zeitsch. der Deutsch. Geol. Gesellschaft*, Bd. xxviii, p. 457, 1876, and Imp. Geol. Inst., Vienna, Sitz. for 1877.

[3] Lambert, "Terrain Crétacé du départ. de l'Yonne": Bull. Soc. Sci. hist. et nat. de l'Yonne for 1876.

[4] Peron, "Terrain de craie dans le Sud-est du bassin angloparisien": op. cit. *supra* (1887).

[5] "Le Terr. Crét. du Sud-ouest," Mém. Soc. géol. France (1877); and "Report of Excursion to the Charente", Bull. Soc. géol. France (1877).

Holaster planus be included in the Upper Chalk or Senonian there will be seven zones without reckoning that of *Ostrea lunata*.

In the following pages I shall endeavour to show that the Upper Chalk or Senonian of England, France, and Germany really contains two distinct faunas, and is consequently divisible into two stages as distinct as the Cenomanian and Turonian. I shall also consider the range of some of the component members of these faunas with the special object of determining the most natural line of division between these two stages.

French geologists long ago recognized the difference between the assemblages found in the lower and upper parts of d'Orbigny's Senonian stage, but they have never tabulated the fossils with the view of demonstrating the precise amount of this difference. They have divided the ancient 'Senonian' into two parts, and have given these parts definite names, but regard them as sub-stages and not as primary divisions of the series. German geologists have also recognized a division into Unter- and Ober-Senon, but they do not adopt the French names and they do not agree as to the horizon at which the plane of separation should be drawn.

To tabulate the whole Senonian fauna would be both a laborious and unnecessary task. If it really comprises two different assemblages, their diversity should be made apparent by a separate tabulation of two or three classes of organisms and especially by the Cephalopoda. This we shall find to be the case, but as Cephalopoda are not everywhere abundant I shall supplement their evidence by that of the Echinoids and the species of the genus *Inoceramus*.

Further, in order that the tabulated lists may be readily compared with one another the zones of the Senonian in England, France, and Germany must be correlated with one another, and as the zonal nomenclature has not yet been unified and perhaps cannot ever be made the same for all three countries, I have prepared a table of equivalent zones for reference.

The French and English zones are easily correlated because we have practically adopted the French zones, but in Germany the case is different. In the latter country the beds which contain typical *Micraster cortestudinarium* are known as the 'Cuvieri-planer' from the abundance of *Inoceramus Cuvieri*, and are placed at the top of the Turonian stage. This zone is overlain by a great thickness of grey marl and marly clay in which there are few Echinoderms, but a large number of *Inocerami* and Cephalopoda, the species indicating that these beds represent our zone of *Micraster coranguinum* with perhaps some of the underlying zone of *M. cortestudinarium*. These marls have been called the 'Emschermergel' from their development near Ems, and Dr. Schlüter regarded them as forming a separate stage between the Turonian and Senonian, but others more correctly consider the special character of the fauna as due to special local conditions of deposition.

The 'Emscher' Beds are succeeded by a set of sandy marls which Schlüter classed as Unter-Senon and divided into three zones, with the indices of (1) *Marsupites ornatus*, (2) *Pecten muricatus*, and (3) *Scaphites binodosus*. The two higher zones correspond with that

of *O. pilula* in the Anglo-Parisian region, but in Germany this Echinid is only found in the overlying zone of *A. quadratus*, so that it cannot be used as an index, and *Scaphites binodosus* may be adopted instead. *A. granulatus* ranges throughout these marls, which are often called the 'granulaten-kalk'.

The Ober-Senon of Schlüter, i.e. the zones of *A. quadratus* and *B. mucronata*, corresponds with the rest of the English Upper Chalk. The equivalence of these zones is shown in the following table, in which I have also inserted the Ammonite zones established by de Grossouvre as an international basis of comparison:—

England.	France.	Germany.	Ammonite Zones.
B. mucronata.	*B. mucronata.*	*B. mucronata.*	*Pachydiscus neubergicus.* / *Hoplites Vari.*
A. quadratus.	*A. quadratus.*	*A. quadratus.*	*Mortoniceras delawarense.*
Offaster pilula.	*Offaster pilula.*	*S. binodosus.*	*Placenticeras bidorsatum.*
Marsupites.	*Marsupites.*	*Marsupites.*	*P. syrtale.*
M. coranguinum.	*M. coranguinum.*	*Emscher marls.*	*Mortoniceras texanum.* / *M. emscheris.*
M. cortestudinarium.	*M. decipiens.*	*I. Cuvieri.*	*Barroisiceras Haberfellneri.*

The reader will now be able to understand the zonal arrangements employed in the following tables and to appreciate the evidence thus presented. It will be convenient to begin with that of the Cephalopoda, and the first table shows the distribution of these fossils in the North of Germany, where they are more abundant than in England or France. This table has been compiled from that given by M. de Grossouvre in 1902[1] with the correction of a few misprints and mistakes:—

TABLE I.

Cephalopoda of the Upper Chalk in North Germany.

Species.	*Cuvieri* zone.	The *Emscher*.	Zone of *Marsupites*.	Zone of *S. binodosus*.	Zone of *A. quadratus*.	Zone of *B. mucronata*.
Mortoniceras Emscheris, Schlüter	-	x	-	-	-	-
M. pseudotexanum, de Gross.	-	x	-	-	-	-
Gauthiericeras Margæ, Schlüter	-	x	-	-	-	-
Peroniceras subtricarinatum, d'Orb.	x	x	-	-	-	-
P. Moureti, de Gross.	-	x	-	-	-	-
P. westphalicum, Stromb.	-	x	-	-	-	-
P. tridorsatum, Schlüter	-	x	-	-	-	-
Barroisiceras Haberfellneri, v. Hauer	-	x	-	-	-	-
Muniericeras clypeale, Schlüter	-	-	x	-	-	-
Placenticeras syrtale, Morton	-	-	x	-	-	-
P. bidorsatum, Römer	-	-	-	x	-	-
Pazosia Mulleri, de Gross.	x	-	-	-	-	-
Desmoceras patagiosum, Schlüter	-	-	-	-	-	x
D. obscurum, Schlüter	-	-	-	x	x	-

[1] "Recherches sur la Craie Supérieur": Mém. Carte Dét. de la France, fasc. ii, p. 790.

SPECIES.	*Cuvieri* zone.	The *Emscher*.	Zone of *Marsupites*.	Zone of *S. binodosus*.	Zone of *A. quadratus*.	Zone of *B. mucronata*.
Sonneratia Dubrécei, de Gross.	-	x	-	-	-	-
Hoplites falcatus (?), Mant.	-	-	-	-	-	x
H. coesfeldensis, Schlüter	-	-	-	-	-	x
H. Vari, Schlüter	-	-	-	-	-	x
H. costulosus, Schlüter	-	-	-	-	-	x
H. lemfordensis, Schlüter	-	-	-	-	-	x
H. dolbergensis, Schlüter	-	-	-	-	-	x
Hauericeras pseudo-Gardeni, Schlüter	-	-	-	x	-	-
Pachydiscus peramplus, Mant.	x	-	-	-	-	-
P. dulmenensis, Schlüter	-	-	-	x	-	-
P. lettensis, Schlüter	-	-	-	-	x	-
P. Stobæi, Nilsson	-	-	-	-	x	x
P. gollicianus, Schlüter	-	-	-	-	-	x
P. icenicus (?), Sharpe	-	-	-	-	-	x
P. Portlocki, Sharpe	-	-	-	-	-	x
P. Koeneni, de Gross.	-	-	-	-	-	x
P. auritocostatus, Schlüter	-	-	-	-	-	x
P. haldemensis, Schlüter	-	-	-	-	-	x
P. neubergicus, Schlüter	-	-	-	-	-	x
P. Wittekindi, Schlüter	-	-	-	-	-	x
Gaudryiceras lunebergense, Schlüter	-	-	-	-	-	x
Phylloceras velledæformis, Schlüter	-	-	-	-	-	x
Scaphites Geinitzi, d'Orb.	x	-	-	-	-	-
S. aquisgranensis, Schlüter	-	-	-	x	-	-
S. binodosus, Römer	-	-	-	x	-	-
S. inflatus, Römer	-	-	-	x	-	-
S. hippocrepis, Dekay	-	-	-	x	x	-
S. gibbus, Schlüter	-	-	-	-	-	x
S. spiniger, Schlüter	-	-	-	-	-	x
S. constrictus, Sow.	-	-	-	-	-	x
S. ornatus, Römer	-	-	-	-	-	x
S. Reussi, d'Orb.	-	-	-	-	-	x
S. Roemeri, d'Orb.	-	-	-	-	-	x
S. pulcherrimus, Römer	-	-	-	-	-	x
S. tridens, Kner	-	-	-	-	-	x
S. nodifer (?), Hagenow	-	-	-	-	-	x
Ancyloceras Cuvieri, Schlüter	x	x	-	-	-	-
A. padebornensis, Schlüter	x	x	-	-	-	-
A. retrorsum, Schlüter	-	-	-	-	x	x
A. pseudo-armatum, Schlüter	-	-	-	-	-	x
Crioceras cingulatum, Schlüter	-	-	-	x	-	-
Toxoceras turonense, Schlüter	x	-	-	-	-	-
Hamites Berkelis, Schlüter	-	-	-	-	-	x
H. recticostatus, Schlüter	-	-	-	-	-	x
H. cylindraceus, Defr.	-	-	-	-	-	x
Turrilites tridens, Schlüter	-	x	-	-	-	-
T. plicatus, d'Orb.	-	x	-	-	-	-
T. varians, Schlüter	-	x	-	-	-	-
T. undosus, Schlüter	-	x	-	-	-	-
Heteroceras polyplocum, Schloth.	-	-	-	-	-	x
Helicoceras reflexum, Quendst.	x	-	-	-	-	-
H. flexuosum, Schloth.	x	-	-	-	-	-

SPECIES.	*Cuvieri* zone.	The *Emscher*.	Zone of *Marsupites*.	Zone of *S. binodosus*.	Zone of *A. quadratus*.	Zone of *B. mucronata*.
Baculites brevicosta, Schlüter	-	x	-	-	-	-
B. bohemicus, Fritsch	x	-	-	-	-	-
B. incurvatus, Dujard	-	x	x	x	-	-
B. anceps, Lam.	-	-	-	-	-	x
B. Knorri, Desor	-	-	-	-	-	x
Nautilus liotropis, Schlüter	-	x	-	-	-	-
N. neubergicus, Redtenb.	-	x	-	-	-	-
N. westphalicus, Schlüter	-	-	-	x	-	-
N. patens, Kner	-	-	-	-	-	x
N. altenensis, Schlüter	-	-	-	-	-	x
N. darupensis, Schlüter	-	-	-	-	-	x
N. loricatus, Schlüter	-	-	-	-	-	x
N. vaalsiensis, Binkh.	-	-	-	-	-	x
Actinocamax pederbornensis, Schlüter	x	-	-	-	-	-
A. westfalicus, Schlüter	-	x	-	-	-	-
A. verus, Müller	-	x	x	x	-	-
A. granulatus, Blainv.	-	-	x	x	-	-
A. Grossouvrei, Janet	-	-	x	x	-	-
A. Toucasi, Janet	-	-	x	x	-	-
A. mammillatus, Nilsson	-	-	-	-	x	-
A. quadratus, Blainv.	-	-	-	-	x	-
Belemnitella mucronata, Schloth.	-	-	-	-	x	x

From this table it will be seen that in Germany there are two very distinct assemblages of Cephalopoda; the one set being almost entirely restricted to the four lower zones, and the other set to the *quadratus* and *mucronata* zones. The one fauna comprises forty-seven species and the other forty-six species, of which only two are common to both, these two being *Desmoceras obscurum* and *Scaphites hippocrepis*. All the commoner and characteristic species of each fauna are absolutely restricted to it.

The passage zone of *S. binodosus* has yielded fifteen species, of which eight are peculiar to it, two range up into the *quadratus* zone, and five range down into lower zones. It will be seen in the sequel that the evidence of the *Inocerami* confirms the inference that this zone is more closely allied to the zone below than to the one above. Hence Dr. Schlüter seems to have been fully justified in drawing the line between his Unter- and Ober-Senon at the base of the *quadratus* chalk.

We will now pass to Belgium and the North of France, where a fair number of Cephalopoda have been obtained, though far fewer than in Germany. The following table shows the range of those which have been recorded from Belgium, the Cotentin, and Touraine, as well as from the Paris Basin proper; but it will be seen that few species are yet known to occur in the zones of *A. granulatus* and *A. quadratus*. In the Paris Basin these zones have not yet been specially examined and searched, except in the neighbourhood of Sens and of Reims; a few remains of Ammonoids have been found

near Sens, but they are so imperfect that de Grossouvre was not able to identify them. No doubt better specimens will be obtained in course of time, and then the evidence will probably tend to coincide more closely with that of the German distribution of species.

In this table the letter F stands for France and B for Belgium.

TABLE II.

CEPHALOPODA IN BELGIUM AND THE NORTH OF FRANCE.

SPECIES.	Zone of *M. cheripeus*.	Zone of *M. coranguinum*.	Zone of *Marsupites*.	Zone of *O. pilula* and *A. granulatus*.	Zone of *A. quadratus*.	Zone of *B. mucronata*.
Tissotia Ewaldi, de Buch.	F.	-	-	-	-	-
T. haplophylla, Redtenb.	F.	-	-	-	-	-
Barroisiceras Haberfellneri, v. Hauer	F.	-	-	-	-	-
Mortoniceras Bontanti, de Gross.	-	F.	-	-	-	-
M. Bourgeoisi, d'Orb.	-	F.	-	-	-	-
M. Emscheris, Schlüter	-	F.	-	-	-	-
M. Zeilleri, de Gross.	F.	-	-	-	-	-
Gautiericeras Margæ, Schlüter	F.	-	-	-	-	-
G. bijuvaricum, Redtenb.	F.	-	-	-	-	-
Veroniceras Moureti, de Gross.	F.	-	-	-	-	-
P. subtricarinatum, d'Orb.	F.	-	-	-	-	-
P. tridorsatum, Schlüter	F.	-	-	-	-	-
P. westfalicum, Schlüter	F.	-	-	-	-	-
Hoplites Lafresnayi, d'Orb.	-	-	-	-	-	F.
Desmoceras ponsianum, de Gross.	F.	-	-	-	-	-
D. Stobæi, Nilsson	-	-	-	-	-	B.
Sphenodiscus Ubaghsi, de Gross.	-	-	-	-	-	B.
Placenticeras Fritschi, de Gross.	F.	-	-	-	-	-
P. syrtale, Morton	-	-	F.	-	-	-
Sonneratia Janeti, de Gross.	F.	-	-	-	-	-
Pachydiscus peramplus, Mant.	F.	-	-	-	-	-
P. telinga, Stoliczka	F.	-	-	-	-	-
P. leptophyllus, Sharpe	-	-	F.	-	-	-
P. colligatus, Binkh.	-	-	-	-	-	F., B.
P. gollevillensis, d'Orb.	-	-	-	-	-	F.
P. neubergicus, Schlüter	-	-	-	-	-	F., B.
P. inopinus, Hébert	-	-	-	-	-	F.
P. parisiensis, Hébert	-	-	-	-	-	F.
Scaphites Lamberti, de Gross.	F.	-	-	-	-	-
S. Meslei, de Gross.	F.	-	-	-	-	-
S. Potieri, de Gross.	F.	-	-	-	-	-
S. constrictus, Sow.	-	-	-	-	F.	F., B.
S. spiniger, Schlüter	-	-	-	-	-	F.
S. Verneuilli, d'Orb.	-	-	-	-	-	F.
S. tridens, Kner	-	-	-	-	-	B.
S. aquisgranensis, Schlüter	-	-	-	F., B.	-	-
S. hippocrepis, Morton	-	-	-	B.	-	-
Ancyloceras Douvillei, de Gross.	-	F.	-	-	-	-
Hamites cylindraceus, Defr.	-	-	-	-	-	F., B.
H. carolinus, d'Orb.	-	-	-	-	F.	-
Baculites anceps, Lam.	-	-	-	-	-	F., B.
B. incurvatus, Dujard.	-	-	F.	B.	-	-
B. Faujasi, Sow.	-	-	-	-	-	B.

SPECIES.	Zone of *M. Hardyi*.	Zone of *M. coranguinum*.	Zone of *Marsupites*.	Zone of *O. pilula* and *A. granulatus*.	Zone of *A. quadratus*.	Zone of *B. mucronata*.
Nautilus Dekayi, Morton	-	-	F.	-	-	-
N. Heberti, Binkh.	-	-	-	-	-	F., B.
N. Le Hardyi, Binkh.	-	-	-	-	-	B.
N. vaalsiensis, Binkh.	-	-	-	-	-	B.
Actinocamax verus, Müller	-	-	F.	-	-	-
A. Grossouvrei, Janet	-	-	F.	-	-	-
A. westfalicus, Schlüter	F.	F.	F.	B.	-	-
A. granulatus, Blainv.	-	-	-	F., B.	-	-
A. quadratus, Blainv.	-	-	-	-	F., B.	-
A. Alfridi, Janet	-	-	-	-	F.	-
Belemnitella mucronata, Schloth.	-	-	-	-	F., B.	F., B.

No definite conclusions can be based on the above list, because so few species of Cephalopoda have yet been found in the zones of *O. pilula* and *A. quadratus*; but so far as the evidence goes it confirms that of the German Cephalopoda, for not one of the species occurring in the four lower zones ranges up into the higher. The zone of *B. mucronata* comprises nineteen species, and this fauna is completely different from that of the beds below the *quadratus* zone.

I have also tabulated the distribution of the Cephalopoda which occur in the corresponding zones of the South of France, Ammonoids being fairly numerous in some areas, especially in the Charentes, the Bordelais, and the Pyrenees. The deposits of Southern France differ so much from those of the northern area that the same zonal terminology is not applicable. Coquand, however, established a number of sub-stages which have again been subdivided by Arnaud, the result being a series of 'assises' which are practically zones. From the tabular view of these divisions and their principal fossils which has been given by de Grossouvre (op. cit., p. 383, table xiv) it is easy to correlate Arnaud's lettered zones with those of the Paris Basin, and from this source I have compiled a separate table of the Senonian Cephalopoda.

To print this table would unduly increase the length of this essay, but I may state some of the facts which are thus brought out. The most important fact is the obvious existence of two different faunas, the four lower zones having yielded no fewer than fifty-three species of Cephalopoda, and not a single one of them ranges into the two higher zones (i.e. of *A. quadratus* and *B. mucronata*), although these have jointly produced twenty-eight species. From the zone of *Placenticeras bidorsatum*, the equivalent of our *O. pilula* zone, eleven species have been obtained of which three are restricted to it, while all the rest range down into the zone below (that of *Placenticeras syrtale*), and none of them range upwards. Here, therefore, the plane of division between the two stages is clearly marked.

England is considered last because so few species of Cephalopoda

have yet been found in our 'Upper Chalk', but so far as their evidence goes it confirms that of France and Germany. In the following table the separate records for the zones of *O. pilula* and *A. quadratus* are based on those given by Messrs. Griffith & Brydone, and on the fact that the highest beds in the Yorkshire cliffs belong to the former zone, though true *A. quadratus* has recently been found by Mr. Stather near Bridlington.

TABLE III.

CEPHALOPODA OF THE UPPER CHALK IN ENGLAND.

SPECIES.	Zone of *M. cortestudinarium*.	Zone of *M. coranguinum*.	Zone of *Marsupites*.	Zone of *O. pilula*.	Zone of *A. quadratus*.	Zone of *B. mucronata*.
Pachydiscus leptophyllus, Sharpe	-	x	x	x	x	-
P. Portlocki, Sharpe	-	-	-	-	-	x
P. icenicus, Sharpe	-	-	-	-	-	x
P. Oldhami, Sharpe	-	-	-	-	-	x
Hauericeras pseudo-Gardeni, Schlüter	-	-	-	x	-	-
Haploceras sp. (aff. *catinus*)	-	-	-	-	-	x
H. obscurum, Schlüter	-	-	x	-	-	-
Lytoceras Jukesi, Sharpe	-	-	-	-	x	x
Phylloceras velledaeformis, Schlüter	-	-	-	-	-	x
Hamites cylindraceus, Defr.	-	-	-	-	-	x
Heteroceras polyplocum, Schloth.	-	-	-	-	-	x
Scaphites binodosus, Römer	-	-	-	x	-	-
S. inflatus, Römer	-	-	-	x	-	-
Baculites Faujasi, Sow.	-	-	-	-	-	x
Nautilus Bayfieldi, F. & C.	-	-	-	-	-	x
N. cf. *atlas*, Whit.	x	-	-	-	-	-
N. darupensis, Schlüter	-	-	-	x	-	-
Actinocamax granulatus, Blainv.	-	x	x	x	-	-
A. verus, Müller	-	x	x	x	-	-
A. westfalicus, Schlüter	-	x	-	-	-	-
A. Toucasi, Janet	-	-	-	x	-	-
A. quadratus, Blainv.	-	-	-	x	x	-
Belemnitella mucronata, Schloth.	-	-	-	-	-	x
B. lanceolata, Schloth.	-	-	-	-	-	x

The total number of species enumerated above is twenty-four, of which twelve occur in the four lower zones and thirteen in the higher, the only Ammonoid which is ostensibly common to the two faunas being *Pachydiscus leptophyllus*; but there is no doubt that several species have been included under this name, and that when they have been differentiated one form will prove to be restricted to the lower zones. The only locality yet known where *A. quadratus* occurs in the zone of *O. pilula* is the Salisbury district, where it prevails, as Dr. Blackmore informs me, to the exclusion of *A. granulatus*.

(*To be concluded in our next Number.*)

VI.—The Younger Rock Series of New Zealand.

By Dr. P. Marshall, M.A., D.Sc., F.G.S., Professor of Geology and Mineralogy in the University of Otago, Dunedin, New Zealand.

In the December number of the Geological Magazine, 1911, pp. 539-49, appeared an article by Professor James Park, F.G.S., on the Lower Tertiaries and Upper Cretaceous of New Zealand. As the author indicates, this article is largely a criticism of a paper on the the Younger Rock Series of New Zealand, written by Mr. R. Speight, Lecturer on Geology, Canterbury College, Mr. C. A. Cotton, Lecturer on Geology, Victoria College, and myself. You will doubtless understand from this statement that with the exception of Professor Thomas,

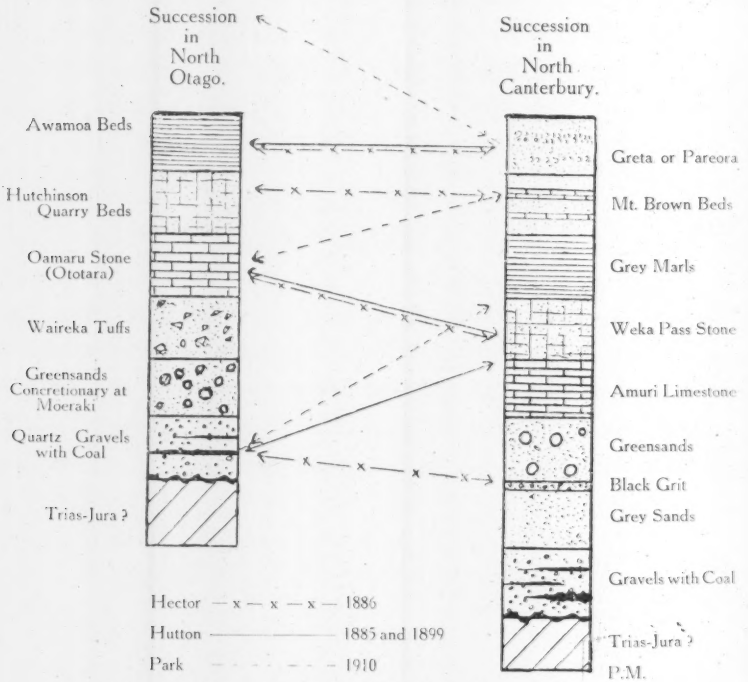


Fig. 1. Comparison of Correlations of Younger Rocks.

of Auckland, with whom we had no opportunity of collaborating, all of those who are at present engaged in teaching geology in the University of New Zealand are co-authors.

This paper was published in the Transactions of the New Zealand Institute, vol. xliii, p. 378, 1910. The great majority of your readers have, of course, not seen this paper, and are not aware of its main contention, nor of the arguments that were adduced in support of it. This is somewhat to be regretted, and I must therefore ask for your permission to restate the gist of these, and also to make

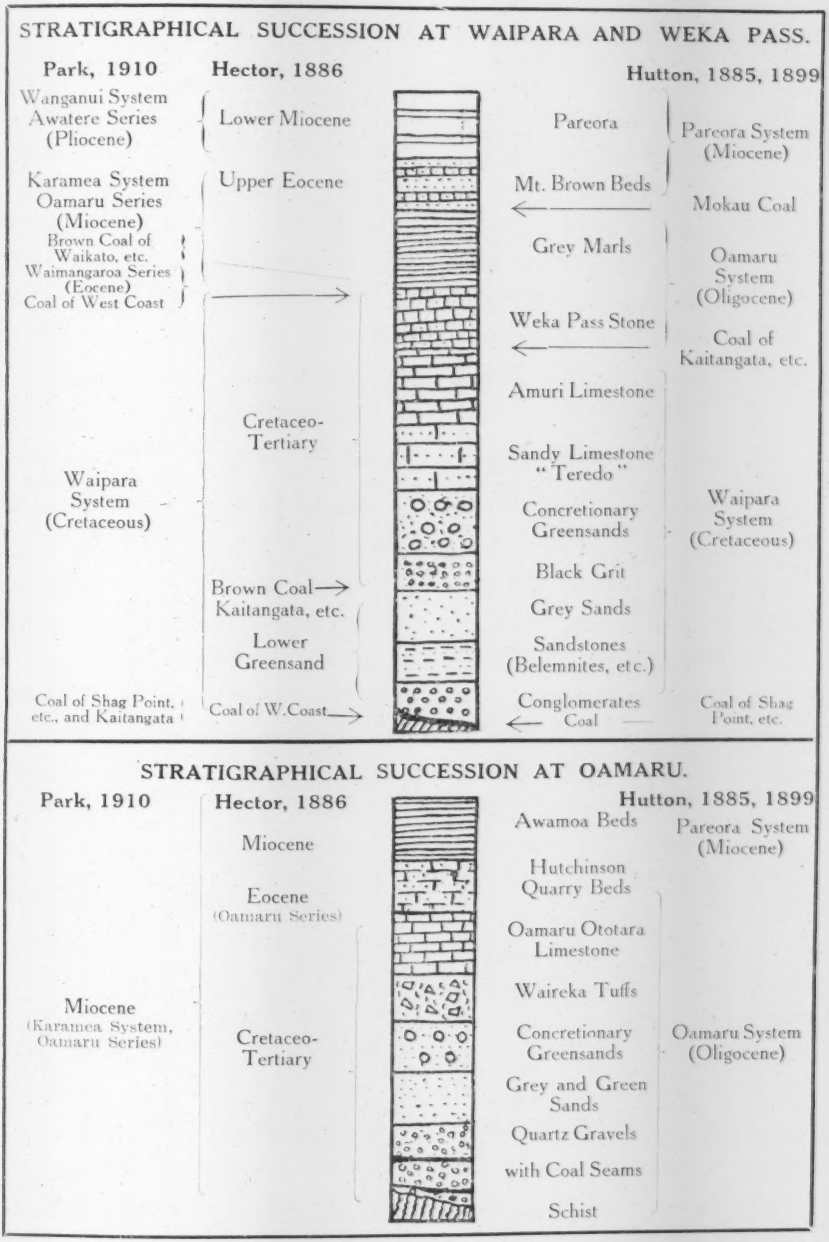


FIG. 2.—These tables (Figs. 1 and 2) are reproduced from the original paper by Marshall, Speight, & Cotton, "Younger Rock Series of New Zealand": Trans. New Zealand Institute, vol. xliii, p. 383, 1910.

further statements and explanations that will refute much of the criticism that appeared in the article referred to.

The history of the various classifications of these strata appears to me to be beside the point, and I shall not refer to it. I should wish to reproduce the two diagrams (see *ante*, Fig. 1, p. 314, and Fig. 2, p. 315), for no objections have been offered to them, and they appear to me to give a correct diagrammatic view of the various opinions that have been and still are held in regard to the stratigraphical position of these beds, and to the correlation of the members as developed in different parts of the country. If these diagrams produce no other impression, they will at least show clearly enough that a great variety of widely diverging views has been expressed in regard to them. Anyone who has not seen the strata in the field will naturally conclude that their arrangement must be highly involved and complex. This, however, is not the case in the most typical localities, for, as Professor Park has said in the most emphatic manner of the typical locality in the Waipara, "The sequence of the beds as just enumerated is the most complete to be found in any part of New Zealand. The stratigraphy is plain and simple, being free from obscurities and offering few points of possible disagreement." Again, "The strata at the Waipara where the complete sequence is exposed are quite undisturbed, following one another uniformly throughout all parts of the district. . . . I am strongly of the opinion that a complete sequence of beds exists from the base of the Cretaceo-Tertiary"—now the base of his Cretaceous—"to the close of the Parcora formation."[1]

Notwithstanding this opinion, with which we cordially agree, unconformities have been described by nearly all observers as occurring in various places in this series. The exact places at which these were described as distinct were visited by us, and the complete evidence of absolute conformity in every case appeared to us to be overwhelming. It is worthy of remark in passing that though Hector, Hutton, Haast, and Park have visited and described the same sections, they have in nearly every case stated that the unconformities described by the others are not present.

The authors of the paper criticized in your article visited the district in company, and in the paper describing our observations gave reasons for believing that the whole series was conformable. In particular, we showed that Professor Park had misread the structure on which his unconformity above the Weka Pass Stone was based, and also that upon which his separation of the Mount Brown and Motanau Beds was based. As regards the latter he at first asserted: "The section exposed in this cutting is of great importance, as here the Motanau Beds are seen to rest unconformably upon the Mount Brown Beds. The section is so clear that no doubt can be entertained as to the unconformable relations of the two formations."[2] In the *Geology of New Zealand* he states: "In the Waipara district the Greta Beds of the Awatere Series are resting unconformably on a highly denuded surface of the Oamaruian."[3] Apparently, however,

[1] Rep. Geol. Explor., 1887, pp. 28, 33.
[2] Trans. N.Z. Inst., vol. xxxvii, p. 538, 1904.
[3] *Geology of New Zealand*, 1910, p. 158.

he has accepted our explanation of the section, for he writes in your article: "The unconformity which I thought I recognized at Waipara between the Mount Brown and Motanau Beds may not exist, or if it does it may be purely local."[1] He offers no criticism of our explanation of the structure that he had described as an unconformity between the Weka Pass Stone and the Mount Brown Beds, and therefore admits the conformable nature of the stratigraphy as insisted upon by us. He does, however, still advocate a palæontological unconformity. "The Ototara Stone is everywhere fossiliferous generally, and its characteristic fossils from one end of New Zealand to the other are *Pseudamusium huttoni*, which is never known to be absent, *Cirsotrema browni*, and *Meoma crawfordi*. The Weka Pass Stone, on the other hand, has never yielded any recognizable fossils." Again, on p. 548, "Moreover, *Cirsotrema browni*, *Pseudamusium huttoni*, and *Meoma crawfordi* are characteristic of the Ototara horizon from one end of New Zealand to the other." On p. 541 the Weka Pass Stone is shown in his tabulated series as the highest member of his Cretaceous (Waipara) Series and the Ototara Stone as the highest member of his Lower Tertiary (Oamaru) Series.

These statements have been quoted here because quite recently Dr. J. A. Thomson and Mr. C. A. Cotton have found *Pseudamusium huttoni*, *Cirsotrema browni*, and Echinoderm remains not sufficiently well preserved for identification within the Weka Pass Stone not two feet from its base.

We thus have a very satisfactory palæontological proof that the Weka Pass Stone and the Ototara Stone are of similar age. Since, in the article referred to, the Waipara Series is represented as perfectly conformable below the Weka Pass Stone, and the Mount Brown and Motanau Beds perfectly conformable above the Weka Pass Stone, we find that this fortunate discovery of palæontological evidence brings Professor Park's position exactly to ours. We feel that it is most satisfactory to have this complete agreement on such a controversial and, to New Zealand geologists, most important matter. This discovery further allows of complete correlation between the Waipara Series and the Oamaru Series, called respectively Cretaceous and Lower Tertiary Series by Professor Park. The Weka Pass Stone is the highest member of the former, and the Ototara Stone is the highest member of the latter, and there is a remarkably similar lithological succession in the two series.

The Weka Pass Stone has been admitted by everyone but Hutton to be conformable to the Amuri Limestone below it. Park, for instance, says: "I carefully examined the line of contact of the two rocks, but was unable to find any evidence of unconformity."[2] McKay has been even more emphatic on this point.[3] The Amuri Limestone is a hardened chalk, formed mostly of broken tests of Globigerina; the Weka Pass Stone is an arenaceous limestone with much glauconite. There is much the same relation between the two rocks as between the Ototara Stone, which typically contains

[1] GEOL. MAG., Dec. V, Vol. VIII, p. 548.
[2] Trans. N.Z. Inst., vol. xxxvii, p. 546, 1904.
[3] McKay, Rep. Geol. Explor. of N.Z., 1886–7, pp. 83–7.

no glauconite and very rarely any mollusca, but an abundance of Foraminifera, and the Hutchinson Quarry Beds, which are nothing more than calcareous greensands above the Ototara Stone. Since Professor Park admits conformity between the two beds at the Waipara and between the Ototara and Hutchinson Quarry Beds at Oamaru, and since its characteristic fossils are common to both, it is obvious that he cannot object to the correlation of the two series, Amuri Limestone with Ototara Stone; Weka Pass Stone with Hutchinson Quarry. This is the correlation which we have adopted, so there must be now substantial agreement on this point also.

Much insistence has been laid on these sections in North Canterbury, because they are perfectly clear and have been admitted as of crucial importance on all sides; Professor Park, for instance, says of it: "The sequence of beds just enumerated is the most complete to be found in any part of New Zealand, and for this reason the Waipara must for ever remain the typical locality for the study of the formations that they represent." [1]

Not only is there a complete conformity at Waipara, but also at the Weka Pass 10 miles away, at Amuri Bluff 70 miles distant to the north-east, and at Oamaru 200 miles to the south. I am perfectly willing to admit that two formations of different ages may locally show apparent conformity; but conformity at places so widely distant in such a similar rock succession cannot fail to convince any geologist that the formations are strictly conformable.

In your article of December, however, the ground is somewhat shifted; for Kaitangata, Shag Point, and Komiti Point are there taken as localities illustrating unconformable stratigraphical relations. Of the first of these it is only necessary to quote: "No actual contact of the Cretaceous rocks and Tertiaries is anywhere exposed." [2] Obviously this unconformity is a matter of inference, and the district is of no critical importance compared with the clear and continuous sections mentioned above.

At Shag Point it is stated in the article referred to that: "The Tertiary rocks form the low bank of a branch of the Shag River near the mouth, well within the influence of tidal flow." Beneath the diagram on p. 543 it reads: "Calcareous sandstone . . . as seen in the north bank of Shag River." Search failed to reveal these beds on the low banks of a branch of the river. They are, however, well known to occur on the south bank of the main river. This is half a mile away from the nearest exposure of the conglomerates of Puke iwi tahi, and the intervening ground shows no rock exposure, and its surface is covered with soil and pasture. On Puke iwi tahi itself the dip is 70 degrees east at the base, and 15 degrees east at the top. Four hundred yards from the top the beds when followed along the ridge have a strike that in this distance bends from north to north-west, that is, through an angle of 45 degrees. One and a half miles distant along the strike from the base of Puke iwi tahi the dip is 75 degrees west in Little Puke. A quarter of a mile to the east of

[1] Rep. Geol. Explor. of N.Z., 1887–8, p. 33.
[2] Geol. Mag., Dec. V, Vol. VIII, p. 544.

Puke iwi tahi the dip changes to the east, and shortly afterwards a complete pericline is developed.

Such changes in the dip and strike show that the rocks are much disturbed, and when the structure of rocks of similar age at Weka Pass is considered, it is reasonable to demand an actual junction to establish an unconformity instead of a difference in dip and strike of two rock exposures separated by half a mile of grass-covered country. This distance would allow of the intercalation of all the members of the rock series in their proper order; but even if a structural break be insisted on a fault offers a more reasonable explanation, as has been shown at length by Cox, Hector, and McKay. Northward from Shag Point along the coast, Hector states that no unconformity was discovered: "Thus completing the succession from the lowest" (conglomerates of Shag Point) "to all but the highest beds of the Cretaceo-Tertiary sequence."[1]

At Komiti Point no work has been done since 1886–7, when Professor Park reported on the district. He says: "At the point opposite Batley they" (Komiti Beds—Lower Miocene) "lie on the upturned edges of the chalky clays belonging to the Inoceramus Beds (certainly Jurassic, p. 229), and on the south side of the Otamatea, opposite Batley, they rest on the hydraulic limestone, but whether conformably or not I was unable to decide, as on account of the shattered and jointed condition of the limestone all trace of the original bedding is now obliterated. However . . . a certain amount of unconformity may be allowed at this point, but the lapse of time that this unconformity would represent must be very limited judging from the very close affinities that exist between the fauna of the Komiti Beds and that of the marly greensands underlying the hydraulic limestone at Pahi."[2] This is the section which twenty-six years later without further description is used to separate the New Zealand Cretaceous from the Miocene, and for the interpretation of the Waipara section 600 miles distant, which must "ever remain the typical section for the study of the formations that they represent".[3]

"The beautiful section near Wade" was not considered of sufficient importance for description when discovered, and has not been described since. It is not even mentioned in Park's *Geology of New Zealand*. However, all such sections are largely beside the point. It is in the district of North Canterbury that the younger series of rocks is most perfectly developed and displayed, and it is universally agreed that conclusions as to their relationships must be based on the perfect and continuous sections there exposed.

In conclusion, will you allow me to state most briefly the reasoned conclusions at which we arrived after a stratigraphical study of the younger rocks of New Zealand.

1. That there is a single rock series which consists of conglomerates, sandstones, greensands, limestone, greensands, grey marls, and brown sands, which is found in more or less complete development wherever the rocks are exposed. Necessarily in some places certain

[1] Rep. Geol. Explor. of N.Z., 1886–7; *Progress Report*, p. xx.
[2] Ibid., 1886–7, p. 228.
[3] Ibid., 1887–8, p. 33.

members may be contracted or even absent while others may be correspondingly expanded in accordance with local variations in the conditions under which their accumulation took place. For instance, the basal conglomerate is not more than 5 feet thick at Amuri Bluff, while at Shag Point the least thickness that has been assigned to it is 1,250 feet. South of Oamaru the grey marls are almost entirely absent, while in the Wanganui Basin they are at least 2,000 feet thick, and their deposition there extended throughout all later Tertiary time. In localities adjacent to the old shore-line greensands and limestones are practically absent.

2. The very nature of the rock succession indicates continuous, uniform, regional depression until after the deposition of the limestone. Thereafter elevation commenced.

3. As a result of this movement of a land surface previously much eroded, the upper strata that were deposited widely overlap those that were deposited earlier.

4. As the shore-line retreated the districts where the basal conglomerates were first deposited became deep-water areas, while conglomerates were still forming on the sea margin which in consequence of the depression had advanced far on to the old land surface. The conglomerates in their different portions therefore represent the various periods that elapsed during the progress of the movement of depression. This consideration seems to me to satisfactorily explain the association of faunas of different ages with the conglomerates. When these basal beds are well known it is reasonable to suppose that the complete development of the Tertiary fauna will be revealed.

5. The fact that conglomerates of different localities contain different faunas does not indicate that two series of rocks are present, but it is the necessary result of the accumulation of sediment on the margin of a gradually retreating shore-line.

6. The coal-seams are always found in the basal conglomerates and associated beds, and may therefore belong to any of the periods that elapsed during the movement of depression. Low-lying littoral districts were constantly being converted into swampy areas where vegetable matter would accumulate, and from this coal would afterwards be formed. Conditions favourable for the formation of coal might occasionally recur during elevation; but the vegetable matter would then not usually be buried, and all superficial deposits would be rapidly eroded.

I hope that this brief résumé sufficiently indicates the radical difference between our explanation and that based upon the Cretaceo-Tertiary classification with which there is a tendency in some minds to confuse it. The Cretaceo-Tertiary classification hypothecated three separate periods of deposition separated by periods of elevation. It placed practically all the coal-seams in the middle of these three periods and thus classed all of them as the same age. This latter idea has now been abundantly disproved.

I may say that although alone responsible for this reply to Professor Park's criticism, it has been submitted to Messrs. Speight and Cotton, and meets with their approval.

VII.—The Cirripede '*Brachylepas cretacea*', H. Woodward.

By Thomas H. Withers, F.G.S.

(PLATE XX.[1])

AMONG the fossil Cirripedia the species '*Brachylepas cretacea*' is of extreme interest, since it affords an important connecting link between the pedunculate and sessile forms. Records of its geographical distribution, moreover, show it to have an exceedingly wide range, but up to the present its vertical range appears to be restricted to the zone of *Belemnitella mucronata* in the Upper Senonian. We owe our knowledge of *Brachylepas* to Dr. H. Woodward, F.R.S., who in 1868 founded the species *B. cretacea* on a single valve under the genus *Pyrgoma*, and in 1901 on a further and more complete specimen established the genus *Brachylepas* and the family Brachylepadidæ. Attention is now drawn to this species mainly on account of the fortunate find of the remaining valves of the capitulum.

In a work on the fossils of the Chalk of Meudon, Ed. Hébert (1855) described and figured what now appears to be a valve of *Brachylepas cretacea*, under the name *Emarginula* (?) *Naissanti*. J. Boehm (1906) called attention to this figure, and considered that it was distinguished from *B. cretacea* only by its smaller size, and that, should further research show that in it we had a young stage of *B. cretacea*, then this form, so widely though sparsely distributed in the Baltic Chalk, would be denoted as *B. Naissanti*, Hébert, sp.

Before seeing Boehm's note I had already formed the opinion that the specimen figured by Hébert as *Emarginula* (?) *Naissanti* was the same species as *Brachylepas cretacea*, H. Woodward. In response to an application from the Geological Department of the British Museum, search for Hébert's type-specimen was most kindly made by the Director of the Muséum National d'Histoire Naturelle, Paris, by Professor Emil Haug of the Sorbonne, and Mr. Léon Bertrand of the École Normale, where most of Hébert's earlier type-specimens are preserved. The specimen, however, could not be found and, as Professor Haug writes, has probably been lost. Fortunately Hébert's figure is quite good and readily recognizable. Moreover, it is so like the figure of *Pollicipes cancellatus* given by Marsson (1880), which Dr. H. Woodward (1906, p. 338) said was undoubtedly the same as his *B. cretacea*, that they might even serve for figures of the same specimen; and the identity of the two latter species is fully borne out by an examination of their type material. The three type-specimens therefore must be referred to a single species under the name *B. Naissanti*, Hébert, sp.

History.—The earliest record of this species appears to be that given by Nilsson (1827) who figured a valve from the Chalk of Scania as "maxilla inferior . . . *Belemnitæ mammillati*". This opinion was held because these valves were found always in association with *Belemnites mammillatus* (= *B. subventricosus*).

Ed. Hébert (1855) thinking that a valve found in the Chalk of Meudon was a portion of an Emarginuloid shell, described and figured it as *Emarginula* (?) *Naissanti*.

[1] Plate XX will appear with the second part of this paper in August.

H. Woodward (1865) called attention to a valve from the Chalk of Norwich, which he considered to be a portion of the shell of a sessile Cirripede belonging to the genus *Pyrgoma*, and for which he proposed the name *P. cretacea*. This valve, discovered by the late T. G. Bayfield, of Norwich, was subsequently fully described and figured by Dr. H. Woodward in 1868.

J. I. Lahusen (1873) described and figured as beaks of a *Nautilus*, two valves, a carina, and rostrum, from the White Chalk of Simbirsk, Russia. He figured also, as *Pollicipes* sp., some valves associated on the same piece of chalk, consisting of a nearly complete scutum, and what appear to be portions of two terga.

Th. Marsson (1880) described and figured under the name *Pollicipes cancellatus* a valve of this Cirripede, which he said was not uncommon in the Chalk of Rügen, is easily recognizable, and not to be confused with any other Cirripede. He described and figured the carina only, but mentioned that he had recognized parts of latera, and probably an upper latus, and part of a tergum. These, however, were said to be too incomplete to permit of the reconstruction of the form of the valves.

W. Dames (1881) in a review of Marsson's paper, said that valves of *P. cancellatus* were not uncommon in the Chalk of Lüneburg, and had also been described by J. I. Lahusen (1873) as beaks of a *Nautilus*, from the White Chalk of Simbirsk, Russia.

F. A. Quenstedt (1883) figured a valve, probably a rostrum, and said that smooth and very broad carinal valves occurred in the White Chalk of Lüneburg, and that these might appropriately be named *Pollicipes lævissimus*.

K. A. Zittel (1885) in his *Handbuch der Palaeontologie*, figured a series of valves from the Upper Chalk of Lüneburg without description under the name *P. lævissimus*, Quenstedt. These valves are respectively called "carina, ?rostrum, scutum, tergum, and lower latera". There are three lower latera, but no upper latus.

H. Woodward (1901) in a further paper on '*Pyrgoma cretacea*' added much to our knowledge of this species, through the discovery by Dr. A. W. Rowe of a remarkable specimen from the *Belemnitella mucronata*-zone of Norwich. This fossil consisted of the carina and rostrum, which were kept in position through the presence of three or four whorls of imbricating plates round the base of the capitulum. From a study of this new specimen of '*Pyrgoma cretacea*', Dr. Woodward concluded that it would have to be removed from the genus *Pyrgoma*, and he based on it the genus *Brachylepas* and the family Brachylepadidæ. He remarked on the absence of the remaining valves, but did not refer to the valves already figured by Zittel (1885). He thought also that scuta, terga, and perhaps a small and narrow latus, completed the capitulum, and he represented these valves diagrammatically in a restoration.

A. Wolleman (1902) noticed some valves from the *Belemnitella mucronata*-zone of Lüneburg, and referred them to *Pollicipes cancellatus*, Marsson. He suggested also that the valves figured by Zittel (1885) as *P. lævissimus* were probably worn valves of *P. cancellatus*.

H. Woodward (1906) remarking on a specimen of *Brachylepas cretacea*, collected by Mr. R. M. Brydone in the Chalk of Trimingham, said: "A careful comparison of Mr. Brydone's specimen with Dr. Marsson's figure on the one hand and with the long series of specimens obtained by Dr. Rowe from the Chalk of Catton, near Norwich, leaves no doubt in my mind that *Pollicipes cancellatus*, Marsson, is identical with *Brachylepas* (*Pyrgoma*) *cretacea*, H. Woodward, 1868, so that *Pollicipes cancellatus* must be treated as a synonym of *Brachylepas cretacea*."

J. Boehm (1906) called attention to a shell-fragment from the Upper Senonian of Haldem, preserved in the Geologisches Landesmuseum of Berlin, and said that it agreed exactly in form and sculpture with H. Woodward's figure of *Brachylepas cretacea* (1901, Pl. VIII, Fig. 4), except that the ribs were thinner and sharper, just as they were in Fig. 4*a*. He said also that the fossil described by Hébert (1855) as *Emarginula*(?) *Naissanti* was distinguished from the preceding only by its smaller size, and that if it should be found to be a young stage of *B. cretacea*, then this form would have to be known as *B. Naissanti*, Hébert, sp.

Distribution of *Brachylepas Naissanti*. Upper Senonian, zone of *Belemnitella mucronata*: Catton, near Norwich, Norfolk; Edward's Pit, Mousehold, near Norwich, Norfolk; Weybourne and Trimingham, Norfolk; Whitway Farm Pit, South Dorset; Isle of Wight; Meudon, France; Isle of Rügen; Haldem, Westphalia; Lüneburg, Hanover; Scania, Sweden; Simbirsk, Russia.

BRACHYLEPAS NAISSANTI, Hébert, sp. (Plate XX.[1])

1827. *Belemnites mammillatus* (maxilla inferior), S. Nilsson, Petrificata Suecana, pp. 9, 10, pl. ii, figs. 2D.
1855. *Emarginula* (?) *Naissanti*, Ed. Hébert, Mém. Soc. géol. France, 2e sér., vol. v, p. 374, pl. xxix, fig. 10.
1866. *Pyrgoma cretacea*, H. Woodward, Rep. Brit. Assoc. (1865), p. 321.
1868. *P. cretacea*, Woodward: H. Woodward, GEOL. MAG., Dec. I, Vol. V, p. 258, Pl. XIV, Figs. 1, 2, 2*a*.
1873. *Nautilus* sp. (beaks of), J. I. Lahusen, Fossils of the White Chalk of Simbirsk; Jubilee Volume of the Imperial Russian Mining-Corps Institute, pt. ii, p. 264, pl. vi, figs. 8, 9.
1873. *Pollicipes* sp., J. I. Lahusen, op. cit., p. 270, pl. vi, figs. 15*a*, *b*.
1877. *Pyrgoma cretacea*, Woodward: H. Woodward, Brit. Mus. Cat. Brit. Foss. Crustacea, p. 141.
1880. *Pollicipes cancellatus*, Th. Marsson, Cirrip. d. Weiss. Schrieb.-Kreide d. Rügen, p. 24, pl. ii, fig. 7.
1880. ?*P. fallax*, Darwin: Th. Marsson, op. cit., p. 22, pl. ii, fig. 6.
1881. *P. cancellatus*, Marsson: W. Dames, Neues Jahrb., Bd. ii, p. 419.
1883. *P. lævissimus*, F. A. Quenstedt, Handb. der Petrefaktenkunde, Abth. ii, p. 467, pl. 37, fig. 13.
1885. *P. lævissimus*, Quenstedt: K. A. Zittel, Handb. der Palaeontologie, Bd. i, Abth. ii, p. 534, fig. 723.
1901. *Brachylepas cretacea*, Woodward, sp.: H. Woodward, GEOL. MAG., Dec. IV, Vol. VIII, p. 150, Pl. VIII, Figs. 3, 4*a*, *b*, pp. 240, 528.
1902. *Pollicipes cancellatus*, Marsson: A. Wolleman, Abh. k. preuss. geol. Landesanst., N.F., Hft. xxxvii, p. 114.
1906. *Brachylepas cretacea*, Woodward, sp.: H. Woodward, GEOL. MAG., Dec. V, Vol. III, p. 337.
1906. *B. cretacea*, Woodward, sp.: J. Boehm, Centralbl. f. Min., p. 449.

Some time ago I was able to obtain a carina, now referred to *Brachylepas Naissanti*, embedded in a piece of bluish-grey marly chalk, said to have come from the "chalk with *Belemnites mucronatus* at Lüneburg, Hanover". To see certain points of structure it was necessary that the inner surface of the valve should be exposed, and the valve was consequently removed from its matrix. When on the point of throwing the matrix away, it was thought, since it was very marly, that it would be easy to wash for Foraminifera. After soaking the chalk, the dirty water was poured off, and to my astonishment a large number of Cirripede valves appeared. Indeed, it seemed impossible that such a small piece of chalk could have completely hidden them. The valves consisted of three nearly perfect carinæ with several fragments, two nearly perfect rostra with portions of others, nine scuta, thirteen terga, five upper latera, all more or less perfect, and about 120 valves of the lower whorls. It is quite possible that had the presence of further valves in the matrix been suspected at first, at least one more or less complete capitulum could have been obtained. This is not at all unlikely, since it was possible

[1] Plate XX will appear in the August Number.

to save some of the lower latera which were still held together by the matrix even after soaking. These valves undoubtedly represent a colony of individuals the remains of which were embedded together, and proof of this is afforded by the fact that the carinæ, rostra, scuta, terga, and upper latera include quite young valves measuring about 2 mm. in size, the others ranging up to as much as 12·5 mm. Moreover, not a single valve of any other species of Cirripede was found with them.

Of the English representatives of *Brachylepas Naissanti*, the carina, rostrum, and lower latera only have been described, these valves being represented in position in the remarkable specimen in the collection of Dr. A. W. Rowe from the *B. mucronata*-zone of Norwich. As already stated in the History (see p. 322), Zittel (1885) figured detached examples of all the valves of this form from the Chalk of Lüneburg, with the exception of the upper latera, under the name *Pollicipes lævissimus*, Quenstedt. Unfortunately he gave no description of them, neither does he say whether they were found separately or associated. In these circumstances, and since these newly found valves complete our knowledge of the capitulum of *Brachylepas Naissanti*, it is here proposed to give descriptions of the several valves, and to discuss what further light they throw on this interesting form.

Carina (Fig. 1) semi-conical, inner margin straight or bowed outwards;[1] apex acute; basal margin semicircular, somewhat concave. Inner surface thickened near the lateral margins, this portion being marked with fine growth-lines, which are continued under the apex to about one-sixth the extent of the valve; these growth-lines indicate the extent to which the valve projected freely. External surface marked with several feebly marked ridges radiating from the apex; these are more pronounced near the apex and die out towards the basal margin. These ridges are crossed by feebly swollen bands, parallel to the basal margin, giving a cancellated appearance to the valve, especially near the apex where the ridges are much sharper. The ends of the transverse ridges give a serrated appearance to the lateral margins.

Rostrum (Fig. 2) semiconical, smaller and proportionally broader than the carina, inner margin straight or bowed outwards. Inner surface thickened near the lateral margins, and marked by growth-lines, which are continued under the apex to about half the length of the valve; the free projection of this valve therefore was proportionally much greater than that of the carina. Outer surface ornamented as in the carina, but more pronounced; and the ridges radiating from the apex, especially in young specimens, give the basal margin a toothed appearance.

Scutum (Fig. 3) almost triangular; occludent margin convex and in its upper part bowed towards the terga; basal margin slightly concave; tergal margin in its upper part slightly concave, and its lower part slightly convex; apex and basi-lateral angle acute. Ad-occludent portion moderately convex transversely, and on reaching a line from the apex to the basi-lateral angle, rising up to form a fold or ridge which on the tergal side is sharply folded downwards and inwards, from which the tergal portion is abruptly deflected. Parallel with the occludent margin, a narrow slip of the valve is bent downwards and forms an indistinct ridge on the upper surface, on which the growth-lines are directed upwards towards the apex. Inner occludent edge thickened, flat, narrow, and marked by lines of growth; a slight ridge runs obliquely from the tergal margin

[1] The carina and rostrum of this Cirripede are either straight or outwardly bowed, a feature that I have observed in certain fossil and recent species of *Pollicipes*. It does not appear to be of specific importance. A rostrum of this species from the Chalk of Norwich in the British Museum (Natural History), registered I. 14028, is considerably bowed outwards.

just below the pit for the adductor muscle, and meets the ridge formed by the inner occludent margin just above the pit, thus forming an obtusely angular depression (marked by lines of growth) for the reception of the tergo-lateral angle of the tergum. External surface marked by somewhat irregular, feeble transverse ridges, which appear to become more regular and prominent in the larger valves.

Tergum (Fig. 5) sub-rhomboidal, divided into almost equal portions by a prominent ridge curving from the apex to the basal angle, formed by the valve being sharply bent along this line; apex pointed and curved towards the scuta; lower part of valve narrow and pointed; upper carinal margin generally considerably convex, and usually shorter than the lower carinal margin; occludent margin shorter than the scutal margin. A portion of the valve along the occludent margin is rounded and protuberant, and is bounded by a depression running from the apex to the scutal margin at a point about one-fourth the distance from the occludent margin, to which extent the valve was overlapped by the scuta; a further indistinct fold or ridge runs from the apex to about the middle of the scutal margin. Valve externally marked with transverse ridges like the scutum, forming an acute angle on the central ridge. Inner surface of upper carinal margin thickened to a very small extent and marked by lines of growth.

Upper latus (Fig. 4) a very acute-angled isosceles triangle. External surface almost smooth, and marked with irregular, indistinct, transverse ridges or periodic lines of growth, more strongly marked on the lateral margins. The lines of growth are continued on the inner surface, where they are very obliquely upturned, and meet on a raised, sharp-edged, median ridge, which extends to the apex. The portion marked with lines of growth indicates the extent to which the valve overlapped the scuta and terga, the raised ridge falling in between; and the small triangular smooth portion near the base indicates the extent to which the valve was covered by the corium or membrane lining the inside of the valves.

Valves of the Lower Whorls.—Although the specimen of *Brachylepas Naissanti*, figured by Dr. H. Woodward as *B. cretacea* (GEOL. MAG., 1901, Pl. VIII, Fig. 4*a*), shows at the base of the capitulum from three to four whorls of imbricating valves in position, little knowledge can be gained of their inner structure. The specimen shows admirably the external arrangement of these valves, as well as their variation in shape and size, and enables one to gain some idea as to the number of valves constituting the several whorls. On the more complete side of the specimen figured there are fifty-four valves preserved, and if we reckon the same number for the other side the total would be 108. In all probability the number was greater, since some of the valves near the carina have a median notch in their basal margin, presumably for the external fixation of another valve.

From the specimens from Lüneburg we learn that the lower whorls of imbricating valves were probably four in number, with a few additional valves below the upper latera. The valves decrease in size outwardly, their bases stand almost on the same plane, and the median ridge of the outer valve closely corresponds to that of the valve immediately in front of it. When the valves were in position their external walls must have inclined at a greater angle than the walls of the carina and rostrum. All the valves have a strong median ridge with laterally divaricating growth-bands, which give to the lateral borders a serrated appearance, a feature strongly marked in certain valves. The median ridge sometimes stands out at the apex as a short spine.

Leaving out of consideration the additional valves below the upper latera, the innermost whorl is composed of valves that have a median semicircular notch in their basal margin (Figs. 7–9); some of these valves (Figs. 8, 9) have their inner surface thickened to form a sharp median ridge extending from the apex generally to about two-thirds the length of the valve, at which point a further ridge extends to each basi-lateral angle; others have their inner surface almost flat (Fig. 7). Surrounding this is a whorl of valves possessing an inwardly projecting angular ledge (Fig. 10), which is fixed into the median notch of the

valve immediately in front of it (Figs. 11–14). This is followed by, perhaps, two further whorls of valves with an inwardly projecting ledge, the extremity of each angular ledge being fixed into the median notch of the valve in front. In this manner the basal ledges join to form a flat shelf or platform extending round the base of the capitulum (Fig. 11*b*).

The valves with a basal ledge vary in shape from an equilateral triangle to one with an acute apical angle, their external basal margin being almost straight and having a median notch. The basal ledge is formed by successive increments in the growth of the valve, and the edges of the several laminæ stand out freely as sharp ridges at the base of the valve. These ledges vary in width, possibly according to the position occupied by the valve, for in some of the smaller valves (Fig. 10) the basal ledge is wider than in others and projects inwards to an extent almost equal to the length of the valve itself. The ledge is angular in shape, and, as can be seen in one (Fig. 10) or two of the more perfect valves, is enlarged and slightly upturned at the apex, and is specially adapted to fix into the median notch of the valve immediately in front of it.

Much light is thrown on the inner structure and arrangement of these valves by the four valves (Fig. 11) still attached to one another. The inner valve (Fig. 11′) without a basal ledge, but with a median notch, is one of the valves of the innermost whorl, and probably occupied a position below the upper latus. This is followed by two valves (Fig. 11″) of the second whorl, which have an inwardly projecting basal ledge; the valve on the right hand, as can be seen in the inner view (Fig. 11*b*), is fixed into the median notch of the valve of the inner whorl by the extremity of its projecting ledge. The third whorl is represented by a single smaller valve with an inwardly projecting basal ledge, which is fixed into the median notch of the valve of the second whorl. This outer valve has a median notch presumably for the external attachment of yet another valve; and the presence of this supports the assumption that there were four whorls of valves at the base of the capitulum of this species. It is probable that the valves without a median notch formed additional valves below the upper latera, and in view of their structure it is difficult to conceive what other position they could have occupied. One of these valves is represented in Fig. 6, and it is much like the valves in the same position in the specimen of '*B. cretacea*', figured by Dr. H. Woodward (1901, Fig. 4*a*). The four attached valves from Lüneburg (Fig. 11) show also quite clearly how the valves with a basal ledge interlocked to form the shelf or platform round the base of the capitulum, and that the bases of these valves stood almost on the same plane. The other valves still attached to each other (Figs. 12, 13) probably occupied a position a little to the right or left of the region below the upper latera, and formed part of the first and second whorls, the valves (Figs. 9, 14) being disposed near the carina, and (Fig. 8) below the rostrum, since in the specimen figured by Dr. H. Woodward the lower latera are longest and narrowest under the carina.

It should be borne in mind that the valves here described and figured not only belong to different individuals, but to individuals in different stages of growth.

(*To be concluded in our next Number.*)

REVIEWS.

I.—Earth Features and their Meaning. An Introduction to Geology for the student and the general reader. By William Herbert Hobbs, Professor of Geology in the University of Michigan. 8vo; pp. xxxix, 506, with 24 plates and 493 text-illustrations. New York: The Macmillan Co., 1912. Price 12*s.* 6*d.* net.

THIS volume may be regarded to a certain extent as a companion to that on the *Characteristics of Existing Glaciers* (noticed in the Geological Magazine for 1911, p. 569). After introductory remarks on the aims of geology and the subdivisions of the science, the author

deals with the figure of the earth and the materials composing the lithosphere, including the formation of crystals. He then passes on to consider the method of formation of rocks, and the contortions, thrusts, and faults to which they have been subjected. Earthquakes, with many instructive illustrations, and seaquakes; the rise of molten rock to the earth's surface, and the formation of volcanic mountains by exudation of lava and by ejected materials forming cinder cones, are next considered, the various subjects discussed so far occupying 148 pages.

More attractive, especially to the general reader, will be the descriptions of earth sculpture, which, including glaciation, occupy most of the remaining parts of the volume. Interesting are the descriptions of rock-weathering, and the author remarks: "How important is the cover of vegetation in retaining the rock mantle and the upper soil layer in their respective positions, as required for agricultural purposes, may be best illustrated by the disastrous consequences of allowing it to be destroyed. Wherever, by the destruction of forests, by the excessive grazing of animals, or by other causes, the mat of turf has been destroyed, the surface is opened in gullies by the first hard rain, and the fertile layer of soil is carried from the slopes and distributed with the coarser mantle upon the bottom lands. Thus the face of the country is completely transformed from fertile hills into the most desolate of deserts where no spear of grass is to be seen and no animal food to be obtained. The soil once washed away is not again renewed, for the continuation of the gullying process now effectively prevents its accumulation." Illustrations are given of a once wooded region in China now reduced to desert through deforestation, and of the 'Bad Lands' of the Colorado Desert.

The life-histories of rivers and the travels of underground waters; the influence of jointed and fractured rocks on the flow of inland waters and on the features produced by marine action (chasms, stacks, etc.), receive attention; so also the action of sun and wind in arid regions. The rise and fall of land are illustrated by evidences of uplifted sea-caves and notched cliffs, raised stacks and beaches, and by drowned rivers and submerged channels.

A large part of the work (140 pages) is devoted to glacial phenomena, including particulars of the Niagara Falls, and thus we find a repetition of much of the information and a number of the illustrations that were given in the author's earlier volume before-mentioned. He has, however, prepared the present work with the view of its serving as a guide to scientific students and tourists in Northern America and Europe who would take the book with them (they would be unlikely to carry two geological volumes); the descriptions and illustrations being selected as far as possible from localities likely to be visited. Prominence is thus given to glaciation because "the larger number of colleges and universities in both America and Europe are surrounded by the heavy accumulations that have resulted from former glaciations".

The concluding chapters deal with lake basins, and very briefly with the origin and form of mountains.

There are appendices containing notes on the quick determination of common minerals, descriptions of common rocks, notes on topographical and geological maps, and suggestions for itineraries.

The illustrations are profuse, well-executed, and effective. References to literature are given at the ends of chapters, and there is a good index.

II.—South African Geology.

Geological Survey of the Cape of Good Hope.—The fifteenth Annual Report of the Geological Commissioners of this Province, under the direction of Dr. A. W. Rogers, contains records of the work accomplished during 1910 (Cape Town, 1911). Dr. Rogers describes portions of the divisions of Beaufort West, Fraserburg, Victoria West, Sutherland, and Laingsburg. In dealing with the physical features he describes the 'pans' or bare, mud-covered surfaces on which water stands to the depth of an inch or so after rain; a few are well-defined, but most are ill-defined, measuring from 500 yards or less to over two miles in width. The clearly marked pans in the district are entirely surrounded by dolerite, the ill-defined and shallow pans occur on mudstone and sandstone. The depressions in the dolerite appear to be due primarily to rapid local disintegration of the rock, and to the wind having probably removed the loose material. Dr. Rogers gives some account of the Beaufort Series, and also of its many vertebrate remains from data supplied by Dr. R. Broom; he also describes the Nieuweveld coal, which occurs in fissures of a sandy mudstone, and near the southern end of great intrusions of dolerite. Professor Schwarz has suggested that the coal was carried to its present position by heated water. Analyses show that the coal, compared with other South African coals, contains low amounts of ash, but usually large amounts of moisture and also of volatile hydro-carbons. Particulars are given of the dolerites and also of granophyres, of the screes resulting from the weathering of the dolerite crags, and of other superficial accumulations.

Mr. A. L. Du Toit contributes an account of Maclear and portions of Engcobo, Mount Fletcher, Qumbu, and Mount Frere, a district formed of the Beaufort and Stormberg Series, with numerous sheets and dykes of dolerite. The higher part of the Stormberg Series consists of the Drakensberg volcanic beds, basaltic lavas with occasional thin beds of sandstone and volcanic ash, 3,000 feet and more in thickness. The great escarpment of the Drakensberg rises from 4,000 to more than 8,000 feet above sea-level. The Molteno Beds, which form the base of the Stormberg Series, beneath the Cave Sandstone, contains seams of coal, many plant-remains (*Thinnfeldia*, etc.), and blocks of silicified wood.

There is also a report by Mr. Du Toit on the copper-nickel deposits of the Insizwa, Mount Ayliff, East Griqualand. In this region the Beaufort Series, consisting of shales, flagstones, and thin sandstones, is penetrated by sheets and dykes of the Karroo dolerites, including gabbro; and the copper-nickel ores are confined, more or less, to the contact of gabbro with the altered sediment, but mostly to the igneous rock. The surrounding Beaufort Beds have been metamorphosed into biotite and cordierite hornfels.

III.—Wisconsin Geological and Natural History Survey.—The results of a *Reconnoissance Soil Survey of part of North-Western Wisconsin*, by Mr. S. Weidman, assisted by Messrs. E. B. Hall and F. L. Musback, have been published (Bulletin No. xxiii, Economic Series, No. 14, 1911). The foundation rocks of the area consist of Pre-Cambrian granite, schists, and quartzite, with Keeweenawan trap; of Potsdam Sandstone with shale and Magnesian Limestone of Cambrian age; and of St. Peter Sandstone and Trenton Limestone of Ordovician age. Superficial formations consist of clays, sands, gravels, and boulder-beds of Glacial age; of loess mainly of wind-drifted character and of later Glacial age; and Alluvial sand and gravel. A clearly printed map shows by colour fourteen kinds of soils over an area of 6,700 square miles, on a scale of one inch to 3 miles.

The soils (a term used to include surface soil and subsoil) are mostly derived from the superficial deposits, glacial drifts, and loess, but partly from the older rocks which appear in ridges and on some of the uplands. The land, however, is mostly of low elevation, few hills rising more than 200 or 300 feet, and occasionally 400 to 500 feet above the valleys. It is remarked that the character of the surface formation (Drift, etc.) is often largely determined by the underlying rock, and hence the various older geological formations are important factors in determining the character of the overlying soils.

Of the fourteen soils, seven are derived from the weathering of glacial drift, one from the loess, and five from the alluvial accumulations, including the 'muck' of the marsh and swamp lands. Twelve of these surface soils, mostly 6 to 8 inches deep, are described as loams, sandy or silty, and the subsoils are mostly of similar character, here and there a little more clayey, or containing in the case of one or two of the variable soils a little more coarse sand or gravel. These loams have been separated mainly on account of the differences in their mode of occurrence and the physical features of the land. The map is thus practically a map of the soils and subsoils, and the mechanical analyses are given from both.

Although large areas are covered by dense growths of woodland, evidence has been obtained to show the uniformity of many of the soils and subsoils over extensive tracts. The object is to point out the general character of the soils, the physical features of the land, and the climatic and agricultural conditions throughout the area. A detailed study of the soils in the populated areas is promised.

IV.—Fossil Human Remains from Peru.—The discovery of prehistoric human bones in the Cuzco Basin in the Central Andes of Peru is announced by Mr. Hiram Bingham, Director of the Yale Peruvian Expedition (*Amer. Journ. Sci.*, xxxiii, p. 297, 1912). The geological relations of the remains are described by Mr. Isaiah Bowman. The floor of the basin is from 11,000 to 11,500 feet above sea-level, and into it flow numerous streams which have dissected the marginal belt of alluvium and also the alluvial floor, bearing down quantities of land-waste. In one of these ravines are exposed the gravel deposits in which the human remains were found. Evidence of the occupation of the higher grounds by man is found in the presence of ashes,

charred corn, broken pottery, bones of many kinds, etc., but no special antiquity can be assigned to these relics. The human bones in question were found beneath from 75 to 150 feet of gravel, portions of which had been eroded. They however afford no proof of great antiquity. With them were bones of *Canis* and *Bos* or *Bison*, and these again afford no proof of antiquity. Moreover, as pointed out by Mr. Bowman, it is within the limits of possibility "that the bluff in which the bones were found may be faced by younger gravel and that the bones were found in a gravel veneer deposited during later periods of partial valley filling". The human remains, which are figured, include parietal bone, ribs, femurs, etc. These and the other bones are described by Dr. George F. Eaton.

V.—Kelvingrove Museum, Glasgow.—*An Introduction to the Study of Fossils and Guide to the Palæontological Collections* in this Museum has been prepared by Mr. Peter Macnair, F.G.S., the Curator. (Glasgow, William Hodge & Co., 1912, pp. 89, price 3*d*.) The first part of this Guide deals with the mode of preservation of organic remains, with the indications they afford of physical conditions and of periods of time, with evolution and classification. Brief descriptions are given of the principal groups of Invertebrata and a few notes are appended on Vertebrata. The collection of fossils is arranged stratigraphically, and the great bulk consists of local specimens, so that in the second part, which deals with Historical Palæontology from Cambrian to Recent times, much more is naturally said about the Palæozoic than the Secondary and Tertiary forms of life. Specimens from the interesting volcanic neck in Arran of Rhætic and Lower Lias fossils are not separated, and the name *Gryphæa incurva* is used on one page and *G. arcuata* on another. Fossil leaves from the Tertiary beds of Mull and Mollusca from the Clyde Beds rightly receive special notice and illustrations. Many figures, indeed, are given throughout the work, and there is a useful index. The Guide has evidently been prepared with care, and should prove very useful to students and other visitors to the Museum.

VI.—Turtle Mountain, Alberta.—In 1903 a great landslide occurred along portions of this mountain, whereby seventy lives of people belonging to the town of Frank were lost, and much damage was done. A report of a Commission appointed to investigate the mountain has been published by the Department of Mines, Canada (Memoir No. 27, 1912). The object of the Commission was to determine whether the continued workings of the coal-mines or independent natural causes are likely to bring about other destructive landslides. The conclusions are that it is not possible to mine within a certain prescribed area without incurring the danger of precipitating a great landslide; and that irrespective of mining operations, and because of existing conditions, there is danger of a similar catastrophe. It is recommended that the greater part of the site of Frank town be abandoned on account of the unstable condition, from natural causes, of the North and South peaks; and if any mining is carried on within the danger area, it should be only under certain conditions, of packing

the excavated areas, of taking not more than 50 per cent of the coal, etc. Numerous diagrams and pictorial views are given.

VII.—Brief Notices.

1. Geological Survey of the Transvaal.—We have received a copy of the excellent colour-printed geological map of portions of Marico and Rustenburg districts in the Transvaal Province, Sheet 9, issued by the Union of South Africa, Mines Department. The map is accompanied by a short memoir by Dr. W. A. Humphrey, entitled *The Geology of the country lying northwards from Zeerust* (Pretoria, 1911, pp. 27). The oldest rocks, igneous and sedimentary, belong to the Ventersdorp System, but occupy only a small area; the Bushveld Plutonic Complex (diabase, norite, and pyroxenite) and rocks of the Transvaal System occupy the greater part of the area, together with a small tract of quartzites, sandstones, and conglomerate belonging to the Waterberg System.

2. National Museum, Melbourne.—No. 4 of the Memoirs of this Museum (1912) contains a description and figures of a new Pecten (*P. præcursor*) from the Tertiary (Barwonian) of Southern Australia, by Mr. F. Chapman; also "Notes on a Collection of Tertiary Limestones and their fossil contents, from King Island", by the same author. In this article remains of a parasitic boring organism, probably a fungus, are described under the name *Palæachlya tuberosa*; other species described, and most of them figured, belong to marine Algæ, Foraminifera, Alcyonaria, Echinodermata, Chætopoda, Polyzoa, Brachiopoda, and Mollusca. The evidence of the fossils leads Mr. Chapman to regard the limestones as belonging to the Janjukian division.

3. Glacial Man.—A well-written review of the evidence relating to this subject has been contributed by Mr. R. S. Lull, Professor of Vertebrate Palæontology at Yale University (*Yale Review*, April, 1912). He refers to the Heidelberg man, as the most ancient known in the Old World, and the remains having been found in association with *Elephas etruscus* might be regarded as Pre-Glacial or Pliocene. Professor Lull comments also on the finding in the same layer of coliths, "implements of the crudest workmanship, if indeed their apparent fashioning is not merely the result of use." In the New World no human bones "of generally accepted geologic antiquity are known".

REPORTS AND PROCEEDINGS.

Geological Society of London.

May 15, 1912.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The specimens (boring cores) exhibited included Silurian from Ware and Cliffe; Silurian or older rock from Harwich and Culford;

Devonian from Tottenham Court Road, Turnford, and Brabourne; Old Red Sandstone from Willesden, Chiswick, Southall, Richmond, Streatham, Beckton, and Crossness; Coal-measures and Carboniferous Limestone from Ebbsfleet, near Ramsgate.

The President stated that, no papers having been ready for presentation at the meeting, he had obtained the consent of the Director of the Geological Survey to exhibit the specimens. He drew attention to many points of interest which came up for consideration. The red rocks reached by the Richmond, Streatham, and Crossness boreholes had been originally classed, with some doubt, as Poikilitic or New Red Sandstone. He had himself, however, always held to the opinion that they were of Old Red Sandstone age and had so entered them in the Table of Borings published in the Report of the Royal Commission on Coal-Supplies; the recent borings at Willesden, Chiswick, and Southall confirmed this view.

Another point of interest to which he specially directed attention was the existence of rocks of Old Red Sandstone aspect, in the same region as rocks with Devonian fossils and of Devonian appearance. It would be of the greatest interest to ascertain the relations of the two types one to the other.

The exhibits included three of particular interest, namely, the rock from the Harwich boring showing a structure which was mistaken for a '*Posidonia*', but which Professor Watts had shown to be an accidental fracture; the Upper Old Red Sandstone fishes which had been obtained by Mr. Procter from the Southall cores; and the Carboniferous Limestone from Ebbsfleet, the first recorded occurrence of that formation in the South-East of England.

June 5, 1912.—Professor W. W. Watts, Sc.D., LL.D., F.R.S., Vice-President, in the Chair.

The following communications were read:—

1. "The Further Evidence of Borings as to the Range of the South-Eastern Coalfield and of the Palæozoic Floor, and as to the Thickness of the Overlying Strata." By Hon. Professor W. Boyd Dawkins, M.A., D.Sc., F.R.S., F.S.A., F.G.S.

In this paper the author gives an outline of the history of the experimental borings made in order to verify Godwin-Austen's theory concerning "the Axis of Artois", which led to the discovery of the South-Eastern Coal-field. The first of these was at Netherfield (1872–5) near Battle (Sussex). Here the borehole, ending in Oxford Clay at a depth of 1,905 feet below the surface, showed that the Palæozoic floor is buried under so great a thickness of rock that it was advisable to look farther north for a site for further experiments. The second boring (1886–92), under the Shakespeare Cliff, Dover, on the site of the Channel Tunnel works, resulted in the discovery of the Coal-measures belonging to the Pennant or Middle Series of the Bristol and South Wales Coal-fields, at a depth of 1,100 feet below O.D. This affords a practical basis for further exploration. The extension of the coal-field to a distance of 8 miles north of Dover was

proved by the boring (1897–9) at Ropersole, where the same Pennant Series occurred at 1,180 feet below O.D., and its extension in the intervening area about 5 miles to the west of Dover by a boring under the direction of M. Breton at Ellinge (1901–2), where the coal-field was struck at 1,286 feet below O.D.

In these three borings the strata of the Coal-measures are practically horizontal, a fact which, in the opinion of the author, implies that they form the bottom of a syncline with its long axis passing from Dover in a north-westerly direction parallel to the scarp of the North Downs.

The boring at Brabourne (1897–8), under the direction of Mr. Brady and the late Mr. Etheridge, gave the next fixed point in the inquiry. It established the fact that, at the base of the North Downs, the Palæozoic floor consists of highly inclined strata (in the opinion of the author, of Devonian age) at 1,789 feet below O.D. These are covered by Dolomitic Conglomerate and Triassic marls, the section being identical with that of the Mendip Hills in Somerset. It therefore marks the position in Kent of the Pembroke–Mendip anticline, which forms the southern boundary of the coal-fields of Bristol and of South Wales. It follows that the south-western boundary of the South-Eastern Coal-field is to be looked for at a sufficient distance east of Brabourne to allow of the presence of the Carboniferous Limestone and Millstone Grit, as shown approximately on the map.

These results, laid by the author before the Royal Coal Commission in 1903, led to further experiments under his direction. The first of these, at Waldershare (1904–7), proved the existence of the Coal-measures at 1,069 feet below O.D., in two distinct groups, the upper belonging to the Pennant Series as before with an average dip of 10°, and the lower with an average dip of 20°, belonging to the lower group of Coal-measures of Somerset, Gloucester, and South Wales. The second, at Fredville (1905–7), three miles north-east of Waldershare, reached the Palæozoic floor at 1,109½ feet, and entered the same lower series of valuable coal-seams, dipping at an angle of 17° (Journ. Roy. Soc. Arts, vol. lv, pp. 456–7. 1907). Further experiments have been carried on north and east of Dover, but their results are not yet available for scientific purposes. Thus a valuable coal-field has been proved over a large area, with its eastern and western boundaries as yet undetermined, as shown on the map.

Two further experimental borings to the north and west, carried out under the author's direction in 1910–11, led to most unexpected results. Hitherto the Coal-measures were either horizontal, or dipping in the normal fashion without signs of faulting, and there was every reason to believe that the Coal-measure trough would be struck on the first site, at Chilham, about three miles south-west of Canterbury. Instead, however, of Coal-measures, Upper Silurian shales with *Monograptus priodon* formed the Palæozoic floor at 1,072 feet below O.D. In the second, at Bobbing, near Sittingbourne, hard Silurian grits and shales occurred at 1,070 feet below O.D. In both borings the Silurian rocks are nearly vertical, and bear marks of crushing. The northern boundary of the South-Eastern Coal-field is

therefore to be sought in the district between Fredville and Chilham, and probably nearer to the former locality than to the latter.

The Silurian portion of the buried Palæozoic floor is then traced westwards through Cliffe, on the Thames below Gravesend, to Ware in Hertfordshire, and northwards through Essex to Harwich, Sutton, and Culford (Bury St. Edmunds). To the south of this the Devonian rocks occupy the area of London, and extend as far as the district of Croydon.

The varying thickness of the overlying rocks is also dealt with, and details are given of three sections, at Ropersole, Chilham, and Bobbing, in the hope that they may be useful to other explorers.

2. "Shelly Clay dredged from the Dogger Bank." By John Walker Stather, F.G.S.

The Dogger Bank fishermen frequently get in their nets a tough peaty material, which they call 'moorlog'. In a paper published in the *Essex Naturalist*, April and July, 1909, this 'moorlog' was described by Mr. H. Whitehead and Mr. H. H. Goodchild, with a report on the plant-remains by Mr. Clement Reid, F.R.S., and Mrs. Eleanor Reid.

In looking over some recently dredged 'moorlog' brought in by a Hull trawler, the author noticed that, adhering to the specimens of 'moorlog', was a dark silty clay, full of marine shells. These specimens of 'moorlog', with the associated shelly clay, were dredged in lat. 55° 24′ N. and long. 3° 10′ E., at a depth of 20 fathoms.

A collection of these shells was submitted to Mr. Clement Reid, who stated that they are all assignable to very shallow-water species, and probably flourished just beneath low-water level. This and other evidence seems to show that the 'moorlog' in this part of the North Sea rests upon a bed of shelly silt, and the shells in the silt together with the 'moorlog' point to great changes of level in the North Sea Basin.

CORRESPONDENCE.

THE CARVED CRAG '*PECTUNCULUS*' SHELL.

Sir,—I am very glad you have admitted to your pages an illustration of the interesting carved shell of *Glycimeris* [olim *Pectunculus*] found in the Red Crag at Walton-on-the-Naze.

Through the kindness of Dr. Marie Stopes I have been permitted to examine the specimen. In common with some others who have examined the shell, I feel sure that it is not a modern forgery, but an ancient work of art; the present fragile condition of the shell and the staining are proofs of that. The sculpturing is not that of a prentice hand, nor, as the marks show, done with a modern or metal instrument.

That it is not of Pliocene age I am also convinced, and would hazard the following explanation of its history.

The surface deposits of the district in which it was found contain palæolithic implements, proving the occupation of the area by primitive man on its elevation above the sea-level.

The Crag in those days would not be in the condition in which we now know it. It had not then been soaked to so great an extent with the iron-charged drainage waters that have percolated it from palæolithic times to the present

day, reducing its shelly contents to their present condition, and anything buried in it then would be similarly changed with the other contents.

A palæolithic man graved the shell (note the breadth of the nose in connection with Professor Sollas' suggestion as to the affinities of cave man—a later man would not have made it so broad); it was buried with the owner in a grave dug down into the Crag, all traces of which interment with the perishable human remains would become obliterated in the subsequent ages, or if any were left would be overlooked by the finder, who was not, I believe, a skilled geologist, and who certainly was not expecting the prize that came in his way.

B. B. Woodward.

PS. Since writing the above I have re-examined the shell with Mr. A. S. Kennard and others. Mr. Kennard pointed out that the hinge-teeth in one place held a small fragment of matrix unlike that of the Red Crag adhering to other parts of the shell, and strongly resembling humus. This little piece of evidence, if correct, will further support the interment theory. Mr. Kennard further considers that the staining in the cuts, especially the mouth, are unlike Red Crag staining, though not modern. It had previously occurred to me that it looked as if red ochre, as known to the ancient hunters, had been rubbed into the cut.

Another friend has favoured me with an attempt to reproduce the carving from memory on a *Glycimeris* shell from the Red Crag of the locality, but his efforts have only served to emphasize the impossibility of reproducing with modern tools and modern conception of the human face, even in caricature, the quaint but characteristic sculpture on the shell in question.

ON A DISCOVERY OF FOSSILS IN THE WEKA PASS STONE, NEW ZEALAND.[1]

Sir,—While not wishing to defend *in toto* the position taken up by Professor Marshall and Messrs. Speight and Cotton on the Younger Rock Series of New Zealand, which has recently been assailed by Professor Park in this Magazine (December, 1911), I should like to announce a discovery of fossils in the Weka Pass Stone which has considerable historical interest. Professor Park in 1905 (Trans. N.Z. Inst., xxxvii, pp. 545–6) and in the paper mentioned stated that he was unable to find recognizable fossils in this rock, and came to the conclusion that the fossils previously reported by Haast and Hutton were probably derived from fallen blocks of the overlying Mount Brown Beds. Professor Park had not had access to the Geological Survey collections, in which there are undoubtedly Tertiary fossils from this rock, and may be pardoned for not recognizing as from the Weka Pass Stone certain fossils in the Canterbury Museum which are labelled simply 'Weka Pass' or 'Waipara'. He is certainly right in maintaining that fossils are not abundant in the Weka Pass Stone, as stated by Haast, for it is possible to search for hours without success. In a recent visit to the Waipara district, however, Mr. Cotton and myself had the good fortune to stumble across several specimens of *Pecten* (*Camptonectes*) *huttoni* (Park), and a single specimen of a *Cirsotrema* allied to *C. lyrata* (Zittel), two of the most characteristic fossils of the Oamaru Series (Lower Tertiary). This discovery proves that Hector, Hutton, and Haast were right in ascribing a Tertiary age to the Weka Pass Stone, and throws back the position to where it was on Hutton's death, viz. that if the Weka

[1] By permission of the Director of the Geological Survey of New Zealand.

Pass Stone is conformable to the Amuri Limestone, there is a Cretaceo-Tertiary formation in New Zealand, while if it is unconformable, there are distinct Cretaceous and Tertiary formations.

J. Allan Thomson.

Mines Department,
Geological Survey Branch,
Wellington, N.Z.
April 26, 1912.

TERTIARY FOSSILS IN THE WEKA PASS STONE, NEW ZEALAND.

Sir,—The discovery of Tertiary fossils in the Weka Pass Stone in the Lower Waipara district, as reported in this issue by Dr. J. Allan Thomson, is of special interest in connexion with the Cretaceo-Tertiary controversy now taking place in New Zealand. On four different occasions I had carefully searched for recognizable fossils in this rock in the typical Weka Pass District without result, and in consequence referred the Weka Pass Stone to the Cretaceous Waipara succession. This discovery, it should be noted, does not in any way affect the argument for or against a Cretaceo-Tertiary succession to New Zealand. What it does is to show that the unconformity between the Lower Tertiary and the Cretaceous must be placed, not above the Weka Pass Stone as done by me, but below it as contended by Hutton. By the aid of a sketch-map kindly made for me by Dr. Thomson I had no difficulty in finding the new fossiliferous locality in the Lower Waipara. Although fossils are scarce I succeeded in finding two fine examples of *Pseudamusium huttoni* (Park) and two of *Cirsotrema lyrata* (Zittel), both typical of the Tertiary Oamaru Series. The fossils occur in the lower third of the Weka Pass Stone, and are usually not many feet above the junction of the Amuri Limestone.

Hutton always contended for an unconformity between the Weka Pass Stone and Amuri Limestone. The latter is a hard grey chalky rock without bedding planes. Its upper surface on which the Weka Pass Stone rests, as seen along the escarpment facing Doctor's Creek in the Lower Waipara where the Tertiary fossils were recently found, is undulating and gently corrugated, and in places broken into angular fragments that have been recemented so as to present a rudely brecciated appearance. But the physical break is nowhere great, and since both the Weka Pass Stone and Amuri Limestone are tilted at the same angle and exposed in the same scarps it is frequently difficult to distinguish any trace of stratigraphical discordance. Nevertheless, the discovery of Tertiary fossils in the Weka Pass Stone is a splendid justification of Hutton's contention. Above Hutton's unconformity the fossils are typically Tertiary and below typically Cretaceous.

In North Canterbury the Lower Tertiary (Oamaru) Series rests on the Cretaceous (Waipara) Series, but in South Canterbury and North Otago it rests only on older Mesozoic or Palæozoic rocks. Where the Oamaru Series rests on these older rocks in the south it always begins with a series of terrestrial beds containing seams of brown coal, but where it rests on the Cretaceous rocks in the Waipara district the terrestrial beds are absent. It would thus appear that marine deposition began first in the north and gradually spread southward as the subsidence progressed. The marine Weka Pass Stone in the north is apparently contemporaneous with the terrestrial brown Coal-measures in the south. When subsidence began at the close of the Cretaceous the first areas to be invaded by the sea would naturally be the old Cretaceous basins, which would explain the early appearance in the north of *Pseudamusium huttoni* and *Cirsotrema lyrata*, both of which it should be noted pervade all the marine beds of the Oamaruian in the south.

The correlation of the Weka Pass Stone and the Ototara (Waitaki) Stone in the south, as urged by McKay, is opposed to the palæontological evidence, for whereas the Pareora fauna underlies the Mt. Brown (Waihao, Waitaki, Duntroon, Ototara) and Kakanui calcareous horizons, it everywhere overlies the Weka Pass Stone.

James Park.

Otago University, Dunedin.
April 30, 1912.